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# CUSTOM PC

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FULL REVIEW

# AMD RADEON RX480

## HANDS ON WITH AMD'S NEW GPU ARCHITECTURE

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**REVIEW:** NVIDIA GEFORCE GTX 1070

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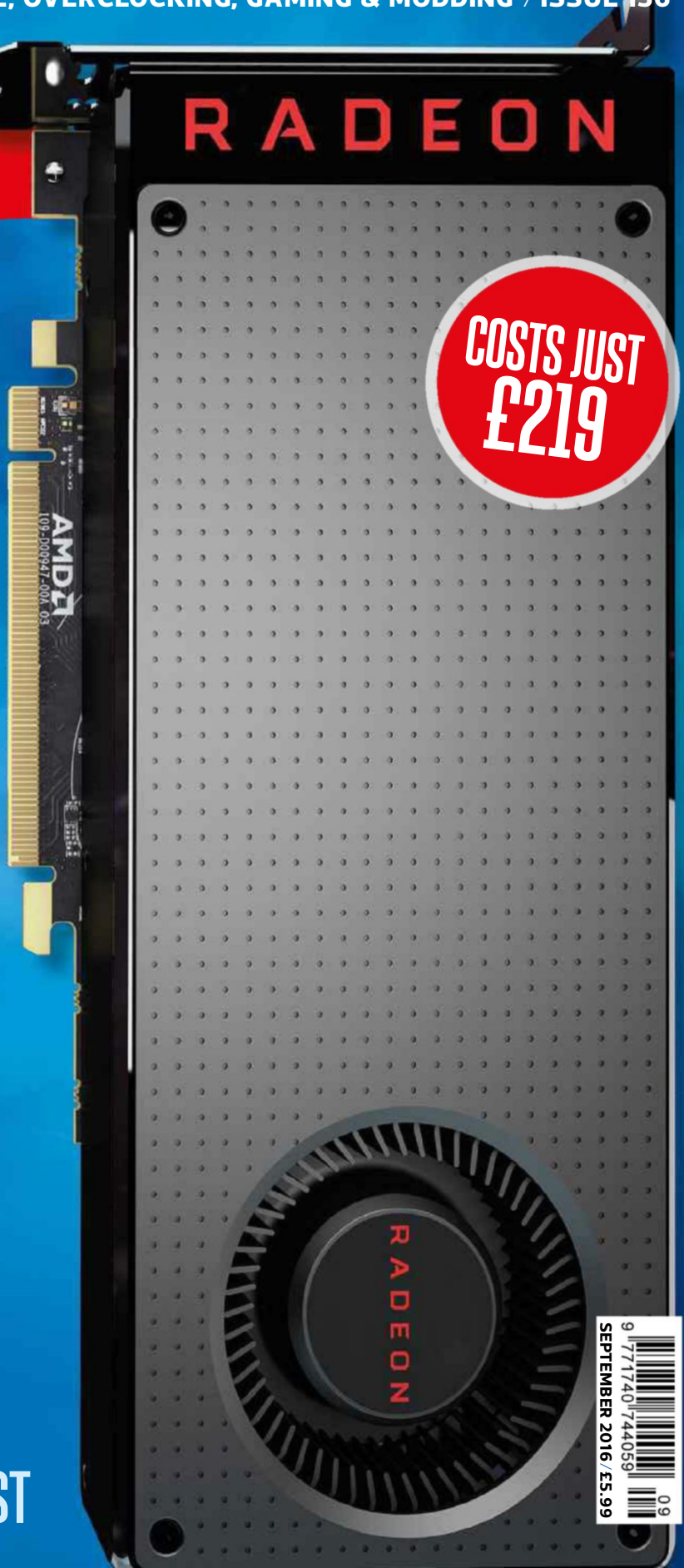


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The new GPU sports 2,304 stream processors, an 1120MHz base clock and up to 8GB of 8GHz (effective) GDDR5 memory. It's a pretty serious spec and, unlike AMD's recent GPUs, it promises power-efficient operation thanks to its smaller transistors.

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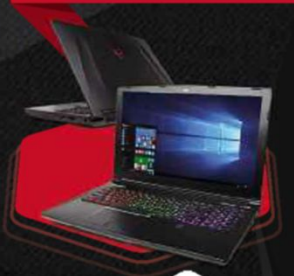

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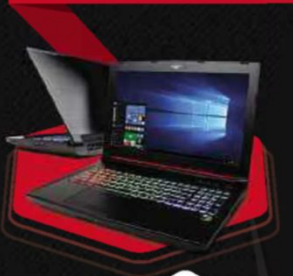

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**BEN HARDWIDGE** / FROM THE EDITOR

# THE ENTHUSIAST CPU FALLACY

The best gaming CPU isn't the most expensive CPU, argues Ben Hardwidge

I was recently shopping for a new mountain bike and, as I ride off-road a lot, and I'm tired of my backside constantly aching, I decided to buy one with suspension on both the front and back wheels. After going around a few shops, though, it became apparent that I couldn't get what I wanted. Apparently the fundamental design of all bike frames is now controlled by one company, which insists that you need to buy a tricycle, rather than a bicycle, if you want full suspension, so all full suspension bikes have three wheels.

This absurd recollection obviously isn't true (although I would like a full suspension bike, naturally!), but it isn't dissimilar to the situation with Intel's current CPU lineups. People who ride tricycles generally have very different requirements from people who ride full suspension mountain bikes. The same goes for gamers and workstation users.

Intel is telling gamers they need to buy a 6-core, 8-core or 10-core CPU if they want all the PCI-E lanes necessary to properly run a multi-GPU array. Okay, so a few people might use multiple GPUs on workstations for compute purposes, but the majority of people building single desktop PCs with multiple graphics cards are gamers.

And gamers don't need all those CPU cores, even for a multi-GPU setup. DirectX 12 might be promising to make better use of multiple CPU cores, but for the moment, the vast majority of games don't use any more than four cores, and most of them only use one or two for most of the work.

An overclocked Core i3 CPU is fast enough for a lot of people's gaming needs, and a quad-core Skylake chip will cover your gaming requirements completely.

An overclocked Core i3 CPU is fast enough for a lot of people's gaming needs

Yet a Core i7-6700K only gives you 16 PCI-E 3 lanes to use for graphics, giving you two 8x slots for SLI – a requirement dictated by Nvidia, which doesn't want SLI setups allocating just four lanes to a GPU. If you want the full 16 lanes for each slot, or to run more than two GPUs with decent bandwidth, you'll need to buy a 40-lane LGA2011-v3 chip. On the plus side, the Z170 chipset has a load of PCI-E 3 lanes to allocate to various storage and I/O functions, so you should at least have storage covered. Also, the GPU performance difference between 8x and 16x slots is admittedly very small in the real world, but there's a weird expectation here – if you want the very best gaming graphics performance, you need to buy a CPU that isn't actually that great for gaming.

Most games load their draw calls onto just one or two cores, meaning a higher-clocked dual-core or quad-core chip will often be quicker in games than a lower-clocked 8-core CPU. As we've discovered on p45, Intel's new Turbo Boost Max 3 technology can give Broadwell-E chips a boost in single-threaded software, such as many games, but it's far from perfect. Look at the results for our GTX 1080 PC Labs on p53, and you'll see that Overclockers' Skylake-based system is regularly quicker in games than the Chillblast machine with an 8-core CPU.

There's a misconception that CPUs with six cores or more are better for gaming, and they're often marketed as 'enthusiast' CPUs, when they're really best suited for workstation use. They might be great chips for multi-threaded video encoding, or for benchmarking, but they're completely the wrong CPUs for gaming, needlessly bumping up the price and not even giving you the highest clock speeds. CPC

**Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Warhammer 40,000.** editor@custompcmag.org.uk @custompcmag

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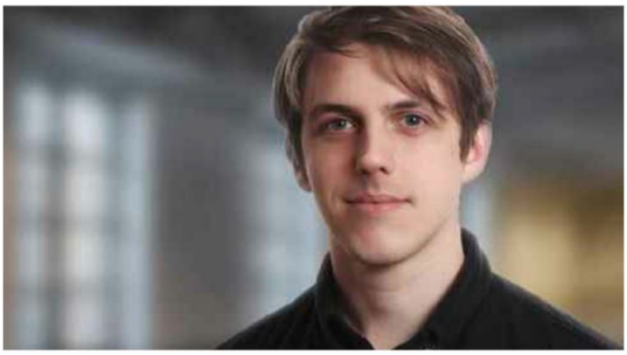

**RICHARD SWINBURNE** / VIEW FROM TAIWAN

# NVIDIA KILLS 3-WAY AND 4-WAY SLI

## And it's about time, argues Richard Swinburne

Despite the rapturous reception to Nvidia's latest GTX 1080 and 1070, Nvidia has also caused a bit of a storm by trying to keep these GPUs' lack of 3-way and 4-way SLI support quiet. Normally I'd cry foul after the sudden loss of a long-term feature, but this time I fully support Nvidia's decision.

Only a tiny fraction of Nvidia's GPU user base uses more than two GPUs. It's just not worth Nvidia's while to spend so much money and resources on R&D, hardware verification and software development for such a small niche of its market. Sure, these people effectively spend 3-4x as much money as everyone else, but they've rarely had a good experience in return for their money.

In addition, **Custom PC** has never recommended 3-way or 4-way SLI for a custom-built system. In fact, you'll be hard pushed to find *any* tech publication that recommends building a 3-way or 4-way SLI rig. Even if you didn't care about such recommendations, you rarely find games benchmarked with three or four GPUs, because such setups are so niche. You might see test results in **CPC**'s Dream PC labs test, but that's about it. For graphics card reviews, you'll see the useful single-card performance reviews, and maybe some limited 2-way SLI testing, but you'll rarely see 3-way or 4-way SLI testing.

> You rarely find games benchmarked with three or four GPUs

Editors and their readers have known for a long time that 3-way and 4-way SLI has never yielded the performance, compatibility or value for money needed to justify the hassle and cost. That budget could always be better spent elsewhere; a faster SSD, new speakers, a new monitor or even a better chair and desk.

It's not like you only have to buy multiple graphics cards to run such a setup either. Intel worked out that it could wring more cash from affluent PC gamers, and started charging a premium for the CPUs and platforms that offer loads of PCI-E 3 lanes. To run 3-way and 4-way SLI, you ideally need an X-series motherboard, plus a seriously expensive CPU with 40 PCI-E 3 lanes, or a special Z-series motherboard with PLX PCI-E multiplier chips. Choosing to run 3-way or 4-way SLI greatly limits your upgrade choices compared with the wider motherboard market.

Nvidia has given ten years of support to this feature, and by culling this niche, it can spend more money improving the single and dual-GPU experience for everyone else. It can put more resources into software such as GeForce Experience and Ansel, as well as driver development and verification, plus its game studio support programs. Almost every Nvidia GPU buyer will ultimately benefit.

Nvidia has left one caveat open for 3-way and 4-way SLI use: non-game benchmarks. Unigine, 3DMark and Catzilla will still be supported, so extreme overclockers can pump out willy-waving super scores to impress their industry sponsors that in turn benefit from the exposure of new world records. It isn't surprising that this support continues, since it keeps those industry partners who compete on aftermarket designs happy. Also, Nvidia's modus operandi is to dominate GPU-related benchmark scores and never give AMD an inch.

Will AMD follow suit? It's already suggested that a pair of RX 480 cards should be competitive with a single GTX 1080 in terms of both price and performance, but there's no word on whether three or four cards could compete with 2-way GTX 1080 SLI. However, given AMD's even more limited resources, it wouldn't be surprising to see AMD following in Nvidia's footsteps. CPC

**Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan** @Bindibadgi

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**TRACY KING** / SCEPTICAL ANALYSIS

# BREXIT GAMES

Tracy King analyses how the recent referendum result could affect the UK game industry

Popular wisdom says you should never talk about politics at a dinner party (or in your magazine column), but we can't avoid talking about Brexit because it has an impact – good and bad – on just about everything. The gaming industry is no exception, and as I firmly believe the secret to a good dinner party politics chat is to look at the facts, that's what I'm going to do here.

The immediate impact of Brexit – the fall in value of the pound – will have an ongoing impact on British game developers, particularly developers who have to pay overseas staff.

The pound will eventually regain value, and some Steam developers who are paid in dollars will have a foreign currency bank account (all British banks offer these accounts), but smaller developers will face increased costs due to inflation that not everyone can afford.

Major developers are better equipped to deal with changes to the economy, of course. Indeed, the game industry has a reputation for being 'recession proof', largely because staying at home is cheaper than going out.

A low pound may result in increased sales abroad as gamers take advantage of a bargain, so it isn't entirely doom and gloom. Physical games may become cheaper for UK customers too, as the cost of imports will fall, although imported hardware may increase in cost, as hardware tends to have smaller margins.

EU funding for video games is at least €20 million, but that's in the form of grants available to all of Europe, not just the UK. One major consideration is the UK's existing video games tax relief system. In 2015, 237 UK games qualified for 20 per cent tax relief, worth around £145 million. This tax scheme required EU approval, and is subject to EU rules. At this stage, no one knows what will happen to the scheme post-Brexit, but equally, no one knows if ditching the EU rules would be bad, or indeed if that's even possible – if the UK wants a free trade agreement then we may have to keep the EU state aid rules too.

A low pound may result in increased sales abroad as gamers take advantage of a bargain

Much of the editorial comment on this issue focuses on potential harm to talent recruitment. Of course, having access to the biggest talent pool possible is good, but I was curious about the figures.

There are currently around 10,000 people employed in the UK in game development, according to BFI figures, and approximately 80 per cent of them are British citizens.

Around 15 per cent (around 1,500 people) are EU citizens; depending on your perspective, this is either a lot of skilled workers to lose, or not a lot to lose, although on a personal level, the impact on morale and future planning for those workers affected is huge.

Equally, UK developers may lose the freedom to work in EU countries, but the future of freedom to work in the EU is another area best summarised as 'no one knows yet'. Back in 2011, the UK game industry was suffering from 'brain drain' as skilled UK workers migrated abroad – one of the problems games tax relief was designed to address – but according to a TIGA report, the majority of that migration was to Canada and the USA rather than Europe.

At this point, no one has the answers. Every 'what if' can be met with a 'but'. Doors will close, but windows will open (that's not a sneaky Microsoft joke, I promise). The only certainty is that anyone claiming certainty, particularly the media, is bluffing. CPC

**Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming** @tkingdoll

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# Incoming

We take a look at the latest newly announced products

## Be Quiet! launches high-end cases

German PC cooling specialist Be Quiet! is expanding its range of PC cases into the premium end of the market, with the new Dark Base 900 series of chassis costing £159 inc VAT for the standard version and £199 inc VAT for a Pro version. Constructed from aluminium and steel, the Dark Base 900 cases feature a modular design, with a removable motherboard tray that the company claims can be installed in six different orientations, while providing room for large E-ATX and XL-ATX motherboards.

Three 140mm SilentWings 3 PWM fans are installed as default, along with noise-insulating foam, and Be Quiet! says the cases are ideal for building quiet systems, while also providing the flexibility needed for water-cooling gear and the airflow for overclocking. Meanwhile, the Pro version features a tempered, tinted glass side window and LED lighting.

## Roccat eyes up couch gaming

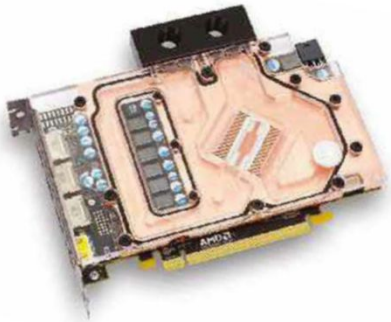
Roccat is eyeing up the lounge gaming business, with its new Sova aiming to bring comfortable keyboard and mouse gaming to the sofa. The Sova includes a built-in keyboard as standard, with both membrane and mechanical flavours available, while the rest of the Sova provides room for a swappable built-in mouse pad, along with a cable channel for your mouse and a pair of USB ports.

The Sova features cushioned padding on its underside, and Roccat promises a 'tried and tested ergonomic palm rest' – a feature that's lacking on Corsair's Lapdog (see Issue 155, p36). The Roccat Sova is available to preorder from **www.amazon.co.uk** now. A version with a membrane keyboard will set you back £120 inc VAT, while £160 inc VAT will buy you a version with a mechanical keyboard using CherryMX Brown switches.

## Corsair lights up memory

Even in these LED-filled times, Corsair clearly thinks your PC can never have enough lights, as it's just launched a new series of memory modules with LEDs in the top. The new Vengeance LED Performance Memory modules are available with either red or white LEDs, complete with a pulsing effect, and have an aluminium heatspreader.

The first modules to launch will run at frequencies between 2600MHz and 3600MHz, but Corsair promises future high-speed kits running up to 4333MHz. The first kits are already available now, with a 16GB (2 x 8GB) 2666MHz Vengeance LED Performance Memory kit costing £76 inc VAT from **www.scan.co.uk**. This isn't the first time Corsair has added LEDs to memory, of course – the company put LED activity meters on XMS Pro memory back in the DDR days.



## Radeon RX480 gets waterblock

AMD's brand-new Radeon RX480 (see p19) had only been out for 29 minutes before EKWB announced a waterblock for it. The company revealed the new EK-FC RX-480 waterblock on its Facebook page on 29 June, with a photo showing the 'very first block, straight from the CNC machine'. The company estimates that the block will cost somewhere around €100 (currently around £84), and should be available to purchase by the time this magazine is in your hands.

As the reference RX480 has a very short PCB, water-cooling it will make the card very small indeed, and will also reduce it to a single-slot design (EK will supply a single-slot backplate too). It might seem a little silly to spend so much money on water-cooling a mid-range GPU, but the end result will be a very small and quiet graphics card that could be ideal for tiny PCs.

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# Letters

Please send us your feedback and correspondence to letters@custompcmag.org.uk

## Measuring decibels

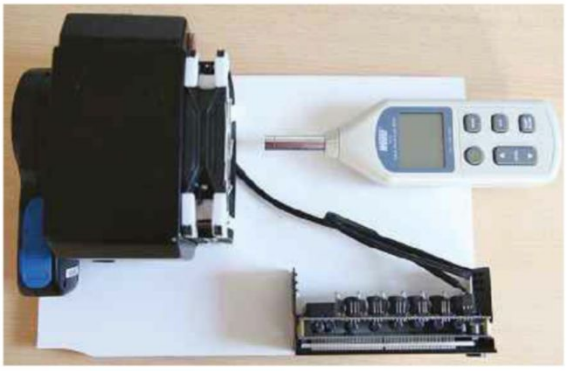
I'm a broadcast sound supervisor and **CPC** subscriber. In your fans test you say sound multiplies by 100 times every 10dBA, but in fact sound pressure level doubles every 6dB (6dB for voltage measured decibels; it's 3dB for watts, but voltage-related scales are always used for practical purposes). So an increase of 12dB is four times louder, 18dB is eight times louder, 24dB is 16 times louder and so on. The same goes for a decrease of -6dB; the sound is halved, so -12dB is a quarter as loud and so on. All we're saying with decibels is that this sound is louder or quieter relative to that sound.

It's fair to say that the human ear perceives an increase of 10dB as a doubling of the sound though. Similarly, +20dB would be perceived as four times louder. You're probably also setting yourself some problems when measuring as close as 2in from the source, although I understand why you would do so. Sound obeys an inverse square law – if you moved twice as close to the sound source, it would be four times louder (+12dB), not twice as loud.

So if your sound pressure meter moved an inch closer from 2in away, your measurement will be four times louder; an inch closer from 1m away would have a much smaller effect on your measurement. By measuring so closely, you're likely introducing a margin of error. I'm also not sure how the air pressure from fans behaves when you get that close to them, but I doubt there would be a uniform sound pressure placing the meter over different parts of the fan (although your measurements may show otherwise – I've never tried it).

Might I suggest that a man of Antony's modding abilities could make his own soundproof testing box, heavily lined with sound-absorbing foam or anechoic material? Or you could use a large, sound-dampened PC case and add to the soundproofing. You would already have a fan mount in there – fix your meter to the other side of the case and the measuring distance will always be the same. You'd also reduce the background noise, and you could put it in a quiet room at home. It's great to see you taking dB readings of fans, though, and also giving subjective opinions on the sound they produce. I hope this has been helpful – feel free to ask me if you have any questions.

**STUART HARRISON**



**Our fan-testing kit includes a noise meter**

**Antony:** Thanks for getting in touch Stuart, and taking the time to reply to email me behind the scenes too. It's the first time we've tested fans in-house, so we expected some teething problems and you're right about the 100dB statement. However, it's good to know that the figures and methodology we used for the actual testing were okay.

The problem we have with moving the sound meter further away from the fans is that, for quiet fan tests, our sound meter isn't sensitive enough to pick them up, even in a quiet room. Meters that can dip below 30dBA are very expensive.

Moving the meter closer is a trick we've seen other reviewers use when testing fans, and so long as the methods, hardware and distance remains the same, the results should be comparable, if not directly so with the manufacturers figures.

Your idea about using a soundproof case is good, though, as it may allow us to move the meter further away, since background noise should also be reduced. We had considered such a setup initially, but the results seemed consistent with our current setup and that particular group of fans, especially as the background noise was just below the levels of the quietest fans on test, which meant we got consistent readings for all of them.

However, in our next fan test group test we'll certainly look at building a more elaborate setup to reduce issues such as wind noise, and also try to source a more sensitive meter – we'll certainly tap into your expertise too!

## PEDANTS' PARADISE

### Not so RealBench

I feel it's finally time that I contacted you for incorrectly displaying my score in the RealBench 2015 leaderboard. I go by the name of Chris_Waddle, and you're displaying me as position three, but I should be in position four. My motherboard is an Asus X99-Deluxe, and my CPU clock is reported. For some reason, you've merged my score with your own **Custom PC** score! Each month I keep expecting to see you notice the error of your ways, but you haven't.

If you could put this right for the next mag I would appreciate it. After you've been telling the world for six months that I have a Rampage V Extreme motherboard, do I get a free one for advertising it as such? Keep up the good work on the mag, I still enjoy the read.

**DAVID HOOLE**

**Ben:** I'm so sorry, David! You're quite correct. I can't give you a Rampage V Extreme motherboard, but I can at least fix the leaderboard – consider it done.

> A man of Antony's modding abilities could make his own soundproof testing box, heavily lined with sound-absorbing foam or anechoic material

## Left cold by active sync

I write in response to your recent labs test on G-Sync and FreeSync monitors. While I'm delighted to see 2,560 x 1,440 monitors getting more popular, I'm left cold by this variable refresh rate thing. The problem for me is that the monitors are 'locked' to either G-Sync or FreeSync. I was looking through back issues of **CPC** prior to writing to you, and James Gorbold's column in Issue 141 mentioned that G-sync was 18 months old then, and it wouldn't be long until we saw manufacturers offering both standards in one monitor. But three years later, I haven't' seen one monitor that supports both standards.

My other problem with the technology was highlighted when I was asked to build a first gaming PC for my friend's son. We plumped for almost exactly your recommendations for a budget PC in last month's Elite list, except he had his heart set on a FreeSync 1080p monitor, which he couldn't afford.

He asked about dropping the graphics card down to a Radeon R7 370, and dropping the SSD. In other words, he wanted to worsen the performance in order to afford a 'gaming' monitor. This is the average person's dilemma. Do you spend more on the graphics card and have better future-proofing, or get 'just enough' and splash out on a variable refresh rate monitor, which limits your GPU choices next time round.

My opinion is that an occasional tear that may disrupt immersion is better than a poorly performing PC which disrupts you every minute of every day. Who is buying these monitors? I've hypothesised that it's people who already have the best GPU available, and have already decided which GPU manufacturer they're likely to stick with in the future. That's a pretty small market.

Manufacturers need to make this technology more relevant for the average user, before it sinks.

**CHRIS HOLLOWAY**

**Ben:** I think of variable refresh rate tech as a luxury, rather than an essential, if you have a tight budget – I wouldn't drop down to an R7 370 GPU just to afford one, particularly as FreeSync only works above certain frame rates anyway (sometimes as high as 40fps), which that GPU would be unlikely to be able to maintain at decent settings. I'd definitely prioritise getting a decent GPU and an SSD, and think about a monitor upgrade later – you're right in that respect. And yes, it's frustrating that active sync tech ties you to one manufacturer, and sadly, it's a situation I don't see changing any time soon.

Active sync tech is fantastic in action though – you maybe need to play with one to appreciate the difference, but it's definitely worth having if you can afford it. Tearing might not seem like a massive issue, but you find it very irritating once you've played games without it. I'm not sure the lack of choice makes the market a small niche either – a lot of monitor makers are producing active sync screens now – there's some fierce brand loyalty among PC gamers. G-Sync is the superior tech of the two, I think, as it continues to work at lower refresh rates, but it does tie you down to using Nvidia GPUs. CPC

**Asus' ROG Swift PG279Q is a great gaming monitor, but it ties you to using an Nvidia GPU if you want to use its active sync tech**

## Twitter highlights

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**sirbenjaminnunn** Finally made the @CustomPCMag @foldingathome Top 50, so I guess I can die happy (and so can my graphics card).
**Ben:** Congratulations!

**mcgeecarl** Really wish I had started sooner...
**Ben:** Nice collection!

**taurisince1983** Issue 155 just graced my door mat with its presence, interesting read as usual! Might try OCing my 1080 later.

**PCEnthusiastUK** Yay! Made it into the top 400 @CustomPCMag @foldingathome contributors :)
**Ben:** Good work!

**WeAreRevHub** It's #Dremel time! Not sure if my plastic Z9 plus front fascia will survive but you've got me inspired!! #PimpMyRig

**WHEN'S THE NEXT MAG COMING OUT?**
Issue 157 of Custom PC will be on sale on Thursday, 11 August, with subscribers receiving it a few days beforehand.

AUG 11

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# Reviews

Our in-depth analysis of the latest PC hardware

**Reviewed this month**


AMD Radeon RX480 8GB p19 / Asus Strix GeForce GTX 1070 OC p24 /

Intel Core i7-6850K and Core i7-6800K p26 /

Corsair Carbide Series 600C p28 / BenQ XR3501 p32 / Custom kit p34

ELITE
NEW ENTRY
P66

GRAPHICS CARD

# AMD Radeon RX480 8GB / £219 inc VAT

**SUPPLIER** www.overclockers.co.uk

Given that Polaris is the star that ancient travellers used to navigate when they got lost, it seems a wholly appropriate codename for AMD's latest GPU, which points a new way forward in a number of ways. For starters, it's AMD's first GPU for over four years that doesn't use 28nm transistors – more on that later.

However, the price is also interesting. Usually, GPU makers launch a new architecture with a flagship, high-end GPU, to claim all the 'fastest graphics card in the world' credits, but AMD's RX480 instead aims to bring VR gaming power to the masses.

Priced at just £219 inc VAT, and with 4GB versions costing well under £200, the RX480 marks a very different approach to Nvidia's latest GeForce GTX 1080 and 1070 cards (see p24). You can see AMD's point. The top-end cards might get all the headlines and praise, but it's the mid-range cards that sell in large numbers. The company pointed out to us that, according to Steam surveys, 95 per cent of gamers play their games at 1080p or below, and that 84 per cent of PC gamers only spend between $100 and $300 US on their graphics card. AMD wants to prioritise that market.

That isn't to say there won't be a top-end new GPU from AMD coming too, but the launch of the company's fourth-generation Graphics Core Next (GCN) architecture is focusing on the mid-range market.

**/SPECIFICATIONS**

**Graphics processor** AMD Radeon RX480, 1120MHz (1266MHz boost)
**Pipeline** 2,304 stream processors, 32 ROPs
**Memory** 8GB GDDR5, 8GHz effective
**Bandwidth** 256GB/sec
**Compatibility** DirectX 12, OpenGL 4.5
**Outputs/inputs** 1 x HDMI 2b, 3 x DisplayPort 1.4
**Power connections** 1 x 6-pin
**Size** 243mm long, dual-slot

## New architecture

AMD's new Polaris GPU isn't quite the brand-new architecture some people were expecting. In fact, in terms of structure, it's very similar to AMD's Radeon R9 300-series chips. However, it breaks ground for the new company by being its first GPU to be manufactured with 14nm FinFET transistors; when compared with the previous 28nm transistors, this means they require less voltage, while reducing leakage and making the chip more power-efficient.

The small size of the transistors also makes an impact. The RX480's die measures just 232mm$^2$, despite containing 5.7 billion transistors – 0.7 billion more than the 366mm$^2$ Radeon R9 380X's die. The result is a graphics card that measures just 243mm across, and requires just one 6-pin PCI-E power connector. The fast-switching transistors also enable higher clock speeds, with the RX480's 1120MHz base clock being higher than that of both the Radeon R9 390X and Fury, and it will also boost to 1266MHz.

In the case of the RX480, the bulk of the chip is split into four shader engines, each of which contain a hardware geometry processors and rasteriser, along with nine compute units. Each compute unit contains 64 stream processors, with four SIMD-16 vector units, four vector registers (4 x 64KB), four texture units (plus 16 texture fetch load/store units), and one scalar unit with a 4KB scalar register. AMD promises a 15 per cent performance increase per compute unit when compared with a Radeon R9 290. The end result is a total of 2,304 stream processors and 144 texture units.

All of the shader engines also share a 2MB pool of L2 cache – twice the size of the cache in the Radeon R9 290X, and the same size as the cache in the Fury X. The Radeon RX480 also represents the Polaris 1 core in its full glory – no shader engines have been disabled to make a cheaper chip, with the promise of a pricier, fully enabled chip coming at a later date – future high-end AMD graphics cards will be based on another new GPU.

**Polaris 1 includes four shader engines, each of which contains nine compute units**

## Memory

While AMD's Fury and chips clearly showed the potential for HBM tech, the mid-range RX480 is instead equipped with GDDR5 memory. Our test sample sports 8GB of memory, but there are also cheaper cards available with 4GB of memory. The memory connects to a 256-bit wide interface, giving you 256GB/sec of bandwidth at the card's 2000MHz (8000MHz effective) memory clock.

Like Nvidia's Pascal architecture, Polaris also sees the introduction of an updated memory controller and lossless colour compression system, which now supports full 2/4/8:1 compression ratios. This should result in less colour data needing to be sent between the memory and GPU, speeding up communication with the memory.

It's fully compliant with Ultra HD video on both Netflix and Amazon Video

## Tweaks

While the Polaris architecture doesn't stray particularly far from that of previous GCN chips, AMD has tweaked it in a few ways to improve performance and efficiency. One example is the enhanced geometry engines, which are now designed to cull any triangles with no area, or without inclusive sample points, early on in the pipeline. It's a small tweak, but one that the company says will result in incrementally faster performance as you add more multi-sampling anti-aliasing.

AMD also promises superior shader efficiency, resulting in the aforementioned 15 per cent performance improvement per compute unit. To achieve this goal, AMD has tweaked the L2 cache behaviour, while a new instruction prefetch system is designed to reduce pipeline stalls and keep information flowing through the pipeline.

The other big feature AMD is trumpeting is asynchronous compute – the ability for a graphics card to efficiently run graphics and compute tasks simultaneously, opening the door to all sorts of GPU bonuses. For example, AMD's new True Audio Next system is designed to use real-time ray tracing techniques to realistically simulate how sound moves and reflects off objects in space – ideal for a room-scale VR system such as the HTC Vive. By using asynchronous compute, however, AMD can assign this audio processing work to compute units at the same time as the graphics processing work, rather than requiring a specific block for audio processing.

## 4K video

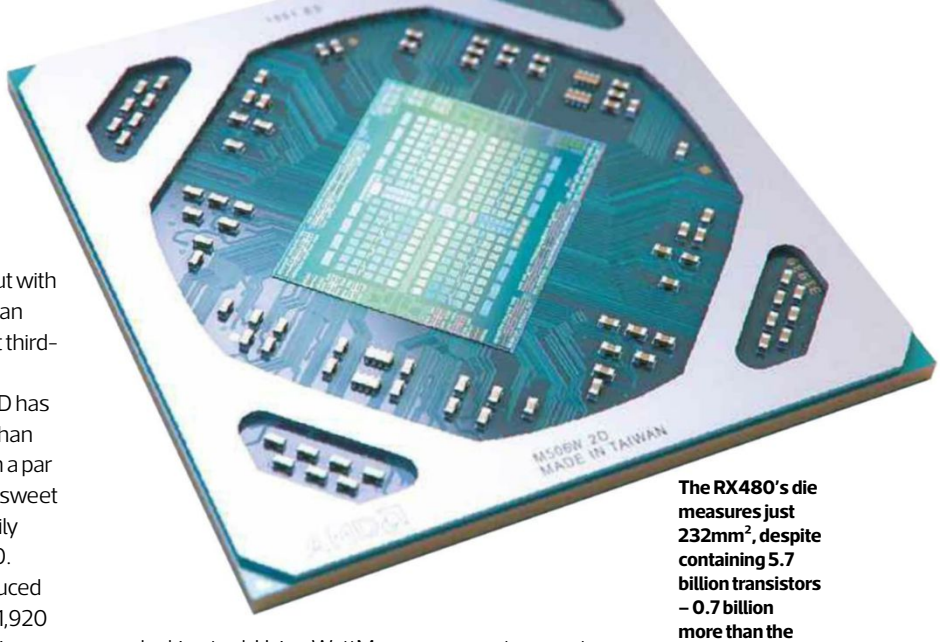
AMD has also addressed some of the video-related shortcomings of some of its previous GPUs, with the RX480 not only supporting HDMI 2, but also the 2b variant, giving you the bandwidth to output full high-dynamic range (HDR) video at 4K with a 60Hz refresh rate. HDR is also supported over DisplayPort 1.4, and the card fully supports 10-bit HEVC. Assuming you have the rest of the necessary gear, this means the card will be fully compliant with Ultra HD video content on both Netflix and Amazon Video.

## The card

We've already mentioned the card's short length of just 243mm, and the PCB only makes up a 178mm of it – the rest is taken up by the cooler. It's a typical AMD reference design, clad in black and red with a single radial fan at the end. The whole card is shaped like a neat oblong – more than one person on the team likened it to a 1980s radio, especially with the pits on the front of the cooler. A single 6-pin PCI-E power connector sits on the top, while the backplate serves up one HDMI 2b port and three DisplayPort 1.4 connectors. The PCB's small size is interesting though. A water-cooled version of the card would be very small indeed.

## Performance

Before we start discussing frame rates and overclocking, we'll get our first complaint out of the way, which is that the AMD reference cooler is horrible. It's fine when you're idle at the desktop, but when the card starts working hard in games, the fan spins up and makes an irritating mid-




**The RX480's die measures just 232mm², despite containing 5.7 billion transistors – 0.7 billion more than the 366mm² Radeon R9 380X's die**

frequency whine – it's a little like the noise of your ears ringing the morning after a loud gig. You can drown it out with a headset or speakers, but if you're considering buying an RX480 card, we recommend buying one with a decent third-party cooler, or even water-cooling it.

With that out of the way, here's the good news – AMD has returned with a bang. It's not only significantly quicker than the old Radeon R9 380 and 380X cards, but it's also on a par with the GeForce GTX 970 – previously the mid-range sweet spot card. In fact, in quite a few tests, the RX480 spookily produced exactly the same frame rates as the GTX 970.

In practice, this means that the Radeon RX480 produced playable frame rates in every one of our test games at 1,920 x 1,080 and 2,560 x 1,440. The only slight wobble was in Fallout 4 at 2,560 x 1,440 at Ultra settings, but even here, its minimum of 29fps is playable, and just dropping the settings down to High will make it much smoother – the GTX 970 performs the same in this test too.

If you're playing at 1080p, the RX480 is great too. It stayed well above 60fps in Doom at Ultra settings at this resolution, and its minimums of 57fps and 58fps in The Witcher 3 and Crysis 3 respectively are great results as well. Of course, The Witcher 3 is one game where Nvidia has the upper hand, enabling you to switch on HairWorks without a huge performance hit, but the RX480 is perfectly competitive in this game with HairWorks disabled.

Not surprisingly, the RX480 can't play games at 4K – it just doesn't have the power for it. You don't expect 4K performance for a £219 graphics card, at least not yet, but higher-resolution performance is what you usually gain from more memory, along with the ability to enable more anti-aliasing, which makes us wonder if you'll get any real-world penalty for opting for the cheaper 4GB card instead of the 8GB one. After all, the Fury X's 4GB of memory can cope fine with games at 2,560 x 1,440, which is the RX480's maximum realistic gaming resolution. The RX480 also passed the SteamVR test, backing up AMD's claims that it can handle VR gaming.

Importantly, and it feels strange to say this about an AMD GPU now, the RX480 was also very power-efficient, with our test system drawing just 77W from the mains when idle, and 243W at full load. Comparatively, the GTX 970 (a card we praised for its power efficiency) pushed our system to draw 266W from the mains in the same test.

AMD has updated its Crimson driver software to help you here. Hit the Global button in the Gaming tab, and you'll see a tab on the right for WattMan; disappointingly, this isn't a half-lightbulb, half-man superhero, but is at least a flexible GPU overclocking tool. Using WattMan, you can set curves to tweak the voltage and core frequency of the GPU, as well as the memory. You can also set the minimum and target fan speed, as well as the maximum and target temperature, while also increasing the power limit by up to 50 per cent.

If you keep WattMan running in the background, you can use it while running various benchmarks, and it will plot several graphs at the top, enabling you to track the peak core temperature and GPU frequency, as well as the fan speed, during gaming sessions. It's a cool feature, and it's great to see AMD officially endorsing overclocking to this degree.

Thankfully, there's a fair bit of headroom for overclocking the RX480 too. The card fell over during our first few attempts at adjusting the core and memory frequency, even by small amounts, and this problem wasn't solved until we'd increased the power limit in WattMan. To eliminate any doubt, we increased this setting to its maximum level (+50 per cent), and also pushed the maximum temperature to 90° and took the fan speed about two thirds up the chart (at which the cooler made a truly horrible racket).

Realistically, you'll be able to achieve a decent overclock without resorting to these extremes, but we wanted to see how far you could push the card in theory. As with Nvidia's Pascal cards, there was plenty of headroom in the memory – we were able to push it up to 2250MHz (9000MHz effective), and it was still perfectly stable. WattMan also enabled us to increase the core clock by 8.5 per cent (peaking at 1375MHz) before the card became unstable.

This overclock pushed up the Crysis 3 from 37fps to 42fps at 2,560 x 1,440, showing you can get plenty more power from this GPU if you push it. You wouldn't want to do it with the reference cooler, but it would be worth doing with a third-party card or a waterblock. These settings admittedly pushed up the power consumption to 329W at load, although you could probably lower the power consumption by spending some proper time tweaking the power limit and voltage settings – sadly, we only had two days to play with our sample before we went to press.

**Using WattMan, you can set curves to tweak the voltage and core frequency of the GPU, as well as the memory**

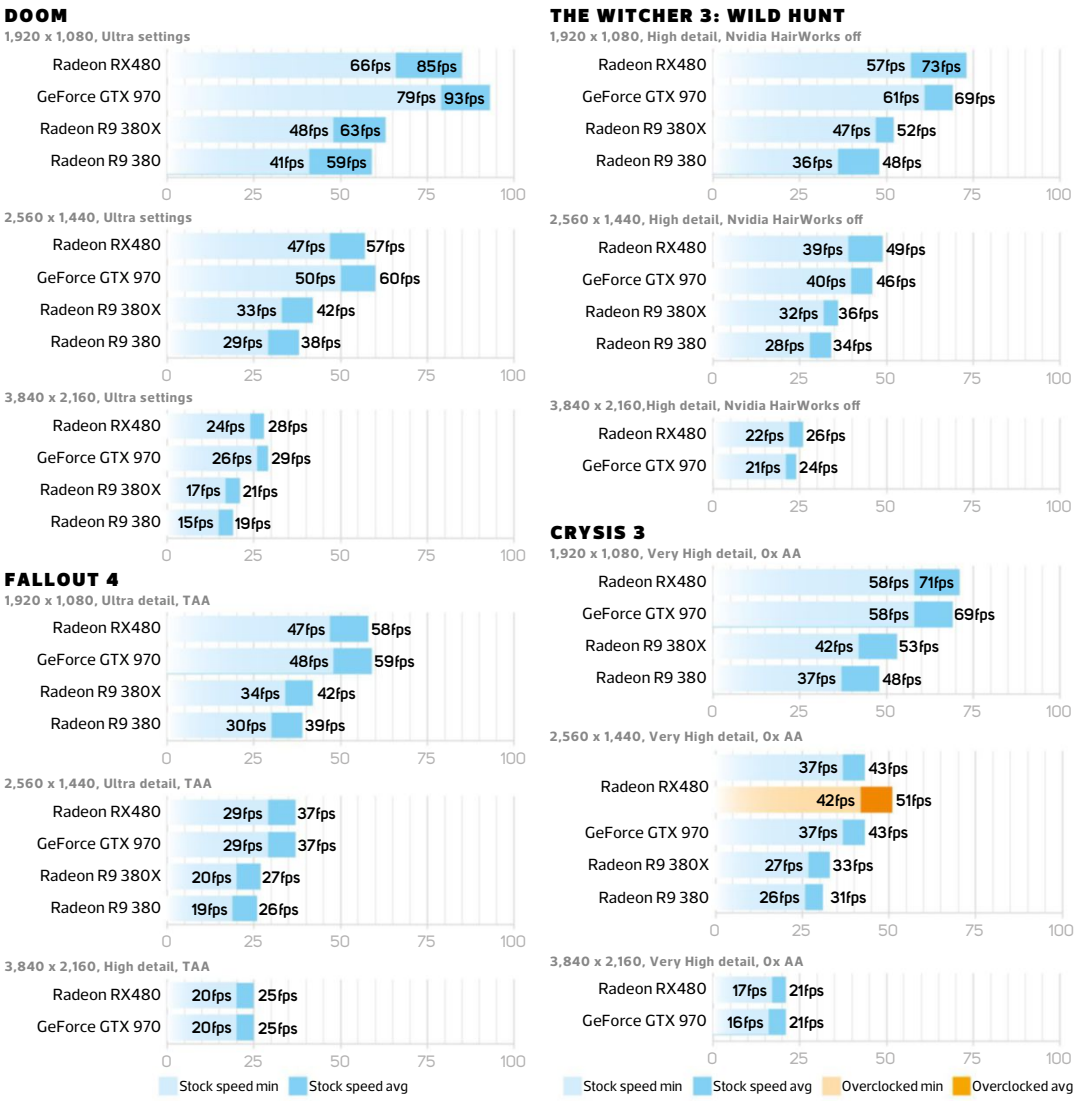
## Conclusion

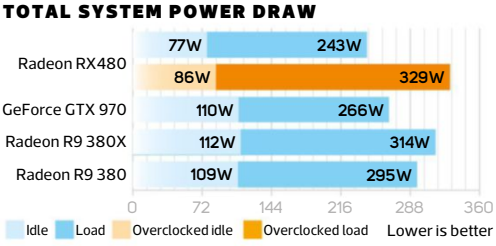
AMD is back! Not only does the RX480 beat the last-generation mid-range Radeons, but it also offers very similar performance to the GeForce GTX 970, with a lower power draw. It may have taken AMD a while to move on from 28nm transistors, but the end result is a fast and efficient mid-range GPU that hits the bang per

buck sweet spot square-on. Perhaps the only problem is that 8GB versions cost almost the same price as 4GB GTX 970 cards now, and the extra memory is arguably wasted at these resolutions. With slightly better power efficiency and more memory, the 8GB RX480 is the superior card for the money, but there's not much in it.

The other problem for the reference design is the cooler, which makes a horrible noise when it gets going. Unless you have good soundproofing on your case, we recommend going for a card with a third party cooler. Otherwise, though, the RX480 represents a cracking return to form for AMD.

**BEN HARDWIDGE**




SPEED **40/50**

VALUE **32/40**

EFFICIENCY **10/10**

OVERALL SCORE **82%**

## VERDICT

A cracking return to form. The RX480 matches the GTX 970's performance with great power efficiency and a reasonable price, although the reference cooler makes a nasty racket.

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GRAPHICS CARD

# Asus Strix GeForce GTX 1070 OC / £480 inc VAT

SUPPLIER www.ebuyer.com

Nvidia is seemingly testing the water with its price label printer at the moment, as if it's gauging just how much people will spend. What would happen if we added another £100? Let's find out! Last month, the GTX 1080 set a precedent with its price of £619 inc VAT, and now the GTX 1070 has turned up in a price league that used to be occupied by the likes of the GTX 980. If you want an overclocked version with a swanky cooler, you'll have to pay even more, with this Asus Strix card costing £480 inc VAT. Is it worth it? In this case, we're going to say yes.

The GTX 1070 is basically a GTX 1080 with three graphics processing clusters (GPCs) instead of four, giving you 15 streaming multiprocessors (SMs), each of which contain 128 stream processors. The total count of stream processors is 1,920 – more than the 1,664 found in the GTX 970, but fewer than the 2,048 in the GTX 980. The GTX 1080 also introduced us to 10GHz (effective) GDDR5X memory, but the GTX 1070 is equipped with familiar GDDR5 memory, albeit with a high 8GHz (effective) clock speed. With a 256-bit memory interface, the total memory bandwidth is 256GB/sec.

If you enable the OC mode, you'll get a 1657MHz core clock

The GTX 1070 reference specification also has a lower core clock than the reference GTX 1080 spec, running at 1506MHz (1683MHz boost), compared to the 1080's 1607MHz base clock (1733MHz boost).

Asus has sorted out that issue on its Strix GeForce GTX 1070 OC card, though, running the core at 1632MHz (1835MHz boost) in its Gaming mode – a hefty 126MHz overclock. Not only that, but if you enable the OC mode you'll get a whopping 1657MHz core clock (1860MHz boost).

Asus and MSI have caught some flak online lately for sending cards to reviewers with the OC mode enabled by default, when retail customers get the Gaming mode by default. It isn't a huge issue, but we tested the card with the OC mode enabled. If you buy the same card, you'll need to enable this mode to get comparable performance. The Asus card only overclocks the core, not the memory.

It's also a massive chunk of tech, measuring 298mm long – you'll need to make sure there's room in your case, especially if you have a middle drive cage installed. Asus has used the space well though. The Strix card sports three large, quiet fans, sitting on top of a bank of fins and heatpipes, backed by a fancy backplate with a Strix logo cut into it. An RGB lighting system sits behind this logo, dubbed Aura, which also lights up the Republic of Gamers logo on the edge and bathes the PCB in your lighting choice. You can set the lighting effect to always on, breathing, strobing, colour cycling or pulsing in time with music. You can even set it to reflect your GPU temperature. It's completely unnecessary, of course, but you can't help feeling some affection for such a beautiful piece of component design.

### /SPECIFICATIONS

**Graphics processor** Nvidia GeForce GTX 1070

**Core frequency** 1657MHz base clock, 1860MHz boost (OC mode); 1632MHz base clock, 1835MHz boost (Gaming mode)

**Pipeline** 1,920 stream processors, 64 ROPs

**Memory** 8GB GDDR5, 8GHz effective

**Bandwidth** 256GB/sec

**Compatibility** DirectX 12, OpenGL 4.5

**Outputs/inputs** Dual-link DVI, 2 x HDMI 2b, 2 x DisplayPort 1.4, SLI

**Power connections** 1 x 8-pin

**Size** 298mm long, dual-slot

## Performance

The Strix GTX 1070 happily beat the Titan X, GeForce GTX 980 Ti and Radeon R9 Fury X at 4K and 2,560 x 1,440 – cards that were seriously expensive when they launched last year. It managed to produce playable frame rates in every one of our test games at every resolution, including 4K. The only slight wobble was in Crysis 3, where the 29 4K minimum is just below the ideal 30 figure.

Even more stunning is the power efficiency. When idle, our system drew just 69W with the Strix 1070 installed, increasing to just 256W at full load. Comparatively, our system drew 381W from the mains with the GTX 980 Ti installed. It's no wonder this card only needs a single 8-pin PCI-E power socket.

There's also room to tweak the card further, especially the memory – we added an extra 275MHz to our sample's memory without any trouble.

With an already decent overclock, there wasn't as much headroom with the GPU core, but could still add an extra 75MHz to its frequency. As with the GTX 1080, this overclock had a negligible effect on power consumption, but it did boost our frame rates, pushing Crysis 3 to a 31 minimum at 4K.

To top it all off, the cooler is very quiet, despite the large overclock, and kept the GPU core below 60°C. While the fans get quicker when the GPU is under load, you hardly notice the difference in noise. It's an excellent design.

## Conclusion

While the GTX 1070 costs much more than the GTX 970 at launch, it has a killer trick, which is 4K gaming. It isn't far behind the GTX 1080 in 4K games, and costs significantly less. You'd need to get into dual-GPU territory to make a significant jump in performance from a single GTX 1070.

The Asus card adds a hefty premium to the GTX 1070's circa-£400 price, and it's arguably too high. If bang per buck is your priority, or if you're water-cooling your card, you can get a GTX 1070 card for less money. If you can afford it, though, this Asus Strix card offers amazing speed, a well-designed cooler and looks great. It's also potentially a great card for VR, thanks to its performance and handy pair of HDMI 2 outputs – one for a TV and one for a VR headset.

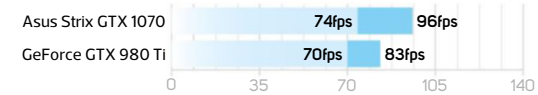
**BEN HARDWIDGE**

**There are two HDMI 2 ports on the back – one for a TV or monitor, and one for a VR headset**

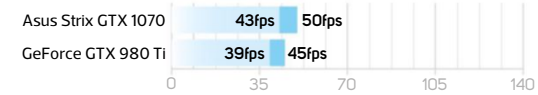
### DOOM

1,920 x 1,080, Ultra settings

2,560 x 1,440, Ultra settings



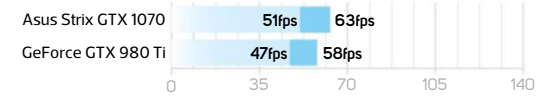

3,840 x 2,160, Ultra settings



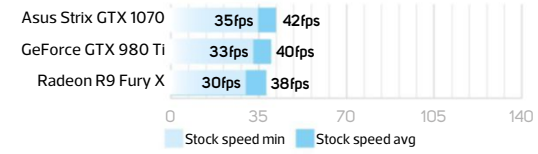

### FALLOUT 4

1,920 x 1,080, Ultra detail, TAA

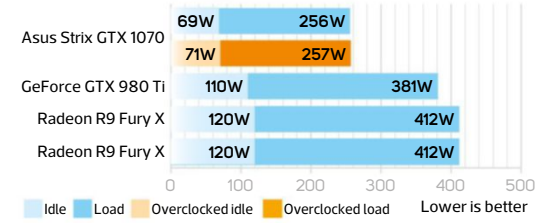
2,560 x 1,440, Ultra detail, TAA




3,840 x 2,160, High detail, TAA

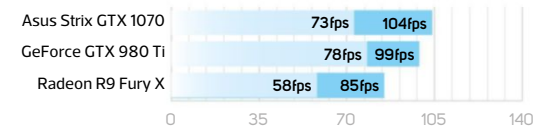



### TOTAL SYSTEM POWER DRAW

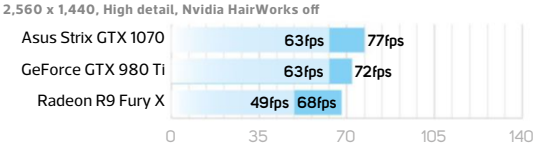



### THE WITCHER 3: WILD HUNT

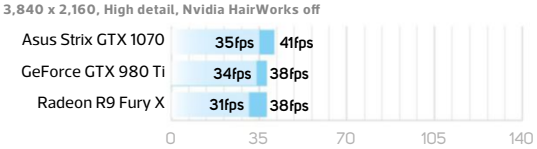
1,920 x 1,080, High detail, Nvidia HairWorks off




2,560 x 1,440, High detail, Nvidia HairWorks off

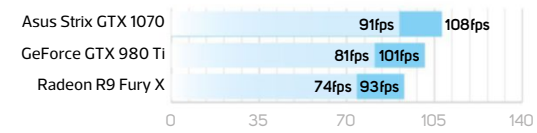



3,840 x 2,160, High detail, Nvidia HairWorks off

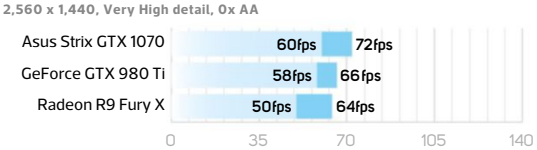



### CRYSIS 3

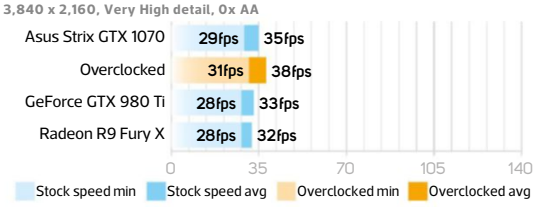
1,920 x 1,080, Very High detail, 0x AA




2,560 x 1,440, Very High detail, 0x AA




3,840 x 2,160, Very High detail, 0x AA




SPEED **45/50**

VALUE **27/40**

EFFICIENCY **10/10**

OVERALL SCORE **82%**

### VERDICT

4K gaming, a cracking cooler design and amazing power efficiency, although this great graphics card is a little overpriced.

INTEL LGA2011-V3 PROCESSORS

# Intel Core i7-6850K / £525 inc VAT
# Intel Core i7-6800K / £380 inc VAT

SUPPLIER www.overclockers.co.uk

While Intel has introduced a fourth member to its latest LGA2011-V3 family of 14nm CPUs, the price range of its Broadwell-E offerings has shifted upwards thanks to the Core i7-6950X – the first desktop 10-core CPU. This £1,400 behemoth is out of reach of most of us and even the next step down – the 8-core Core i7-6900K – is the direct successor to the already pricey Core i7-5960X, and retails for close to £900. So if your wallet is quaking at the thought of building an X99 system, there are two cheaper options – the Core i7-6850K and Core i7-6800K.

The Core 6850K offers the same 40 PCI-E 3 lanes as its £900 sibling

Both are 6-core, Hyper-Threaded CPUs, so their 12 threads will be more adept at handling multi-threaded tasks than the Core i7-6700K, which has four cores and eight threads. Both CPUs have 15MB of Level 3 cache and support Turbo Boost Max 3 as well as having the same TDP. There's quite a price discrepancy between the two CPUs, though, and that isn't just down to the 200MHz difference in clock speed – 3.6GHz for the 6850K compared to 3.4GHz for the 6800K.

The latter is also the replacement for the Core i7-5820K, so it has 28 PCI-E 3 lanes, rather than 40, which will limit you to a 16x/8x configuration with 2-way SLI or CrossFire configurations, while the 40-lane Core i7-6850K will be able to give you 16 lanes for each slot. The performance difference here isn't likely to be huge but, as we've seen with a number of motherboards in this month's motherboard Labs test (see p40), dipping below 40 PCI-E lanes can also limit your storage options. Speed can be reduced when using M.2 and U.2 ports, some of which share bandwidth with graphics slots or are completely disabled when you use a 28-lane CPU such as the Core i7-6800K.

However, both CPUs cost considerably less than the Core i7-6900K, where you'll be lucky to see change from £900. The Core 6850K offers the same 40 PCI-E 3 lanes as its £900 sibling, but costs just £500. It still offers more processing power than the Core i7-6700K, although it only has six cores and 12 threads compared with the eight cores and 16 threads of the Core i7-6900K. Clearly, the latter has a fair amount more grunt, but half the reason for opting for an X99 system is to get the additional PCI-E lanes, and the Core i7-6850K does this for £400 less.

### /SPECIFICATIONS

**Frequency** Core i7-6800K – 3.4GHz; Core i7-6850K – 3.6GHz

**Turbo frequency** Core i7-6800K – 3.6GHz; Core i7-6850K – 3.8GHz

**Core** Broadwell-E

**Manufacturing process** 14nm

**Number of** cores 6 x physical, 6 x virtual

**Cache** L1: 10 x 32KB instruction cache, 10 x 32KB data cache; L2: 10 x 256KB; L3: 25MB

**PCI-E 3 lanes** Core i7-6800K – 28; Core i7-6850K – 40

**Memory controller** Quad-channel DDR4, up to 128GB 2400MHz

**Packaging** LGA2011-v3

**Thermal Design Power (TDP)** 140W

**Features** Turbo Boost Max 3, Turbo Boost 2, Hyper- Threading, Virtualization (VT-x), Virtualization for Directed I/O (VT-d), VT-x with Extended Page Tables (EPT), Intel 64, Idle States, Enhanced SpeedStep, Smart Response, Intel AES

The Core i7-6800K, on the other hand, doesn't offer anything above a Skylake system when it comes to multi-GPU bandwidth. The main reason to buy the 6800K is if you want a 6-core CPU that won't break the bank, and at £380, it offers a pretty good deal on that front. However, unless you regularly run heavily multi-threaded software, you'll be better off saving some money and opting for a Skylake system instead. The 6800K is also the ideal companion for the only X99 mini-ITX board available – ASRock's X99E-ITX/ac – as that board can't accept more than one graphics card anyway.

## Performance

The performance of these cheaper Broadwell-E chips was fairly predictable. Additional cores helped with rendering and video encoding in tests such as Cinebench and our Handbrake video encoding test, and the Core i7-6850K and Core i7-6800K stretched out a significant lead over the Core i7-6700K in these tests. Despite the latter performing better in the mainly single-threaded image editing test, the Broadwell-E chips still held out with system scores of 155,614 and 143,672 respectively, while the Skylake CPU only managed 133,668.

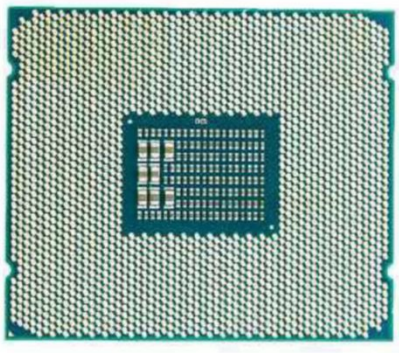
Out of the new bunch of Broadwell-E CPUs, the 6850K has the highest base frequency, so it wasn't surprising to see it beat the 6800K in our image editing benchmark. It also stretched out a small lead over the slower-clocked Core i7-6800K in all tests at stock speed, thanks to its 200MHz advantage in base and Turbo-Boost frequencies.

As with the Broadwell-E CPUs we reviewed in our last issue, both the cheaper chips also topped out at 4.4GHz when overclocking, with our samples requiring 1.34V vcores to be stable. Needless to say, 1GHz and 800MHz overclocks aren't to be sniffed at, resulting in some substantial gains in our benchmarks. The 6850K's system score rose by nearly

ELITE
NEW ENTRY
P66

10 per cent to 169,489 and it was a similar story in the individual tests. The Cinebench R15 score for the same CPU rose from 1,242 to 1,366. The 6800K was very nearly level with the 6850K's results once overclocked too.

Interestingly, disabling SpeedStep also boosted the result in the image editing test, which rose from 54,131 to 67,170. The idle power consumption was 20–30W higher without SpeedStep enabled, but forcing the cores to their maximum frequency is clearly beneficial in lightly threaded tasks.



**The 6800K and 6850K have the same amount of cache and the same number of cores**

## Conclusion

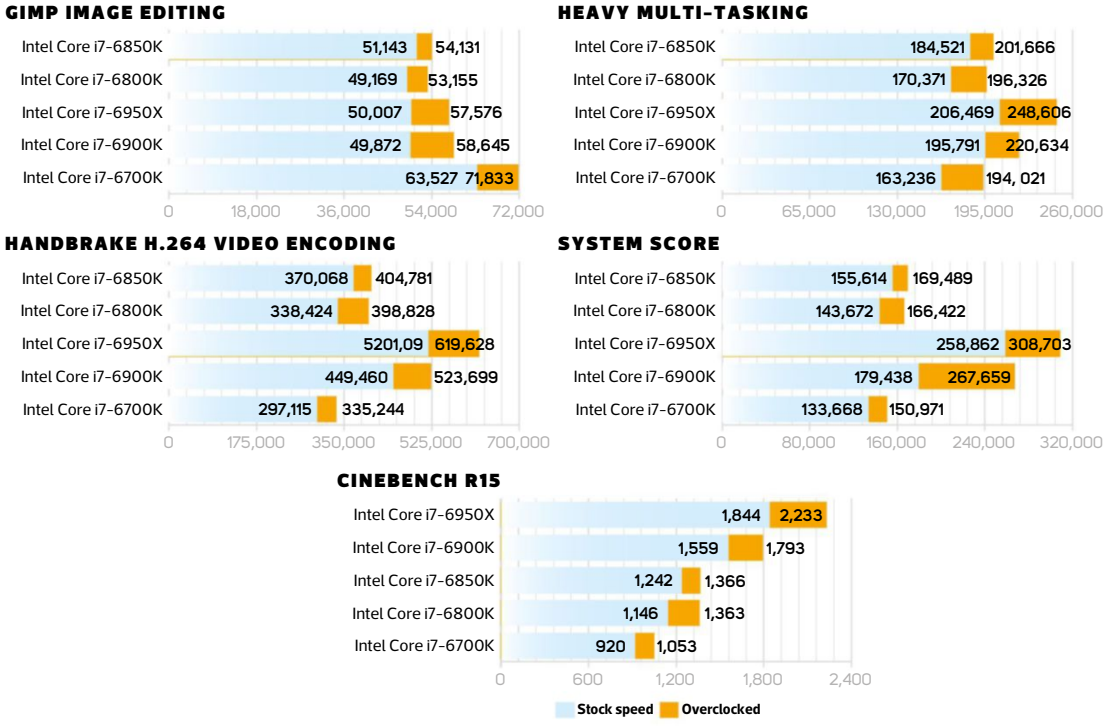
Broadwell-E and X99 is a premium platform that you should only consider if you regularly use heavily multi-threaded software or if you plan to build a multi-GPU rig, and your priorities here will dictate your choice of CPU. The Core i7-6850K is very attractive, as it ticks both these boxes, performing much better than the Core i7-6700K while costing less than £250 more. In this light, it offers significantly better value for money than the Core i7-6900K.

Meanwhile, the Core i7-6800K is ideal if you only plan to use one GPU (along with a PCI-E 3 SSD) and your priority is getting a 6-core CPU for the cheapest price, and it fills this niche well, especially when it's overclocked.

If your main priorities are gaming and standard, everyday software, though, you'll be better off saving yourself some money and buying a quad-core Z170 Skylake system instead.

**ANTONY LEATHER**

### CUSTOM PC REALBENCH 2015




### INTEL CORE i7-6850K

SPEED 43/50 | FEATURES 12/15 | VALUE 27/35

OVERALL SCORE 82%

### INTEL CORE i7-6800K

SPEED 42/50 | FEATURES 10/15 | VALUE 29/35

OVERALL SCORE 81%

### VERDICT

Both CPUs offer decent multi-threaded speed for a reasonable price, but the 6850K's extra PCI-E 3 lanes hits the sweet spot in these days of PCI-E storage.

### /TEST KIT

Asus X99-A II motherboard, 32GB Corsair 2666MHz Vengeance LPX DDR4 RAM, 256GB Samsung 850 Pro SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

ATX CASE

# Corsair Carbide Series 600C / £120 inc VAT

SUPPLIER www.box.co.uk / MODEL NUMBER CC-9011079-WW

We've criticised Corsair's cases for being a little bland in the past, and the company has clearly been listening not just to us, but enthusiasts too, who are spoilt for choice with edgy cases from the likes of Phanteks and In Win. Corsair's latest sub-£100 in the Carbide series, the 400C, didn't fare too badly in our last case Labs test (see Issue 154, p45). However, there is a bigger, more feature-packed version – the 600C, which does go some way to ironing out the issues we had with its smaller sibling.

For starters, the 400C suffered from a lack of features, but the 600C does quite well here. It has the same large clear side window and rather featureless front panel, but in addition to offering double the USB ports on the top panel, two of which are USB 3, the 600C has a three-speed fan controller. The latter is powered by a single SATA power connector and has three fan headers – enough to power all the included fans – and it's easy to set up. It's great to see Corsair including this feature, as many of its cases lack fan control and instead rely on the company's Link software that's only bundled with its all-in-one-liquid coolers.

The case's sizeable dimensions mean it can house E-ATX motherboards, and it can accommodate eight expansion slots too, although at nearly 54cm tall, it's quite lofty and it's one of the wider cases we've seen too at 26cm. It also weighs 10kg, thanks to the plastic and steel construction. The plus side of the large size, though, is that the CPU cooler height limitation sits at a massive 200mm and there's 370mm clearance for graphics cards too.

Meanwhile, the front panel may look like a larger version of the featureless expanse on the 400C, but the top of it houses a door that reveals two external 5.25in bays, which are useful for water-cooling reservoirs or more advanced fan controllers as well as an optical drive if you still use one. Internally, there's plenty of space for water-cooling gear too, with two 120/140mm fan mounts in the front, occupied by a pair of 140mm fans, which supports up to double 140mm-fan radiators with essentially no depth limit.

There are another two 140mm (or three 120mm) fan mounts in the base, with support for a corresponding radiator. The base mounts are spaced a fair way from the motherboard too, although half-height radiators would be more logical in this location. There's a third 120/140mm fan mount in the rear of the case as well, which is home to a third 140mm fan acting as an exhaust; air is drawn into the case via large side vents at the front.

In contrast to the 400C, the 600C's interior has an inverted ATX layout, so the CPU sits at the bottom, with the graphics card above it and the PSU at the top. The latter is hidden by a similar cover to the one in the 400C, which hides unsightly cables and drive bays. As with the 400C, it's tricky to remove the cover, but there isn't much need to do so, as the two front 5.25in drive bays and two 3.5in bays behind them are all tool-free, with drives inserted from different sides, while the three 2.5in tool-free mounts sit behind the motherboard tray. The latter allow SSDs to simply click into place, without any pesky screws.

While most of the case is riveted together, you can remove the roof and front fascias. Removing the latter gives you access to a large removable dust filter underneath, with another on the underside of the case. Being a Corsair case, cable routing is, not surprisingly, also excellent, with a good deal of room between the rear panel and motherboard tray for hiding cables, plus a big cavity in the roof.

## Performance

We were pleasantly surprised by the quiet operation of the three 140mm fans at their lowest speed. If you want a low-noise case that can house a tonne of hardware, then the 600C is compelling, especially as the temperatures only rose a few degrees at the low speed setting. The CPU delta T rose from 54°C to 58°C and the GPU delta T increased a little less noticeably from 51°C to 53°C. Even at their worst, these results are still very competitive.

For example, the CPU delta T was still cooler than the best results from the Corsair Carbide 400C, In Win 503 and Phanteks Eclipse P400S, although the In Win 303, Be Quiet! Silent Base 600 and NZXT H440 all did better. Whack the fan speed up to full, where noise is certainly increased but not by much, and the 600C is only 1°C off the top results we've seen. Meanwhile, the GPU temperature was excellent, even at low fan speeds, thanks to one of the large 140mm fans pointing directly at it.

### /SPECIFICATIONS

**Dimensions (mm)** 215 x 480 x 500 (W x D x H)
**Material** Steel, plastic
**Available colours** Black
**Weight** 10kg
**Front panel** Power, reset, 2 x USB 3, 2 x USB 3, stereo, mic
**Drive bays** 2 x 3.5, 3 x 2.5in, 2 x 5.25in
**Form factor(s)** E-ATX, ATX, micro-ATX
**Cooling** 2 x 140mm/120mm front fan mounts (2 x 140mm fans included), 1 x 140mm/120mm rear fan mount (140mm fan included), 2 x 140mm or 3 x 120mm bottom fan mounts (fans not included)
**CPU cooler clearance** 200mm
**Maximum graphics card length** 370mm

HOW WE TEST
PAGE 38

1 **This cover keeps the PSU, cables and drive bays hidden, although it can be tricky to remove**

2 **The inverted layout means the cutout around the CPU socket is at the bottom**

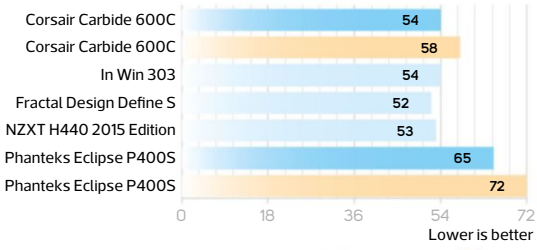
3 **Three quiet 140mm fans are included as standard, resulting in solid air-cooling performance**

## Conclusion

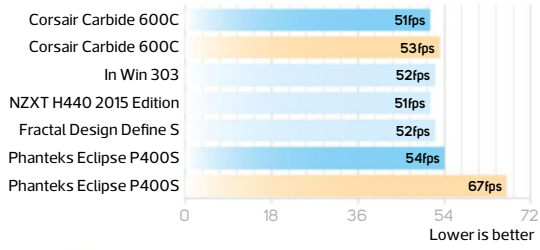
The 600C is a tad clunky in some areas, and it also lacks extensive lighting, but the design is mostly solid, as is the build quality and cooling. It's easy to build a system in it and there's plenty of room for expansion, either as a multi-GPU air-cooled system, or a water-cooled behemoth. Combining water-cooling support with good air-cooling performance is tricky, but the 600C manages it. It's also a good-looking case with all the usual mod cons, including a useful fan controller and three 140mm fans as standard. It's slightly lacking in a few areas for its price tag, especially compared with the likes of the gorgeous In Win 805 and excellent Phanteks Enthoo Luxe, but it strikes a great balance between the two.

**ANTONY LEATHER**

**CPU LOAD DELTA T**




**GPU LOAD DELTA T**




Fixed fan speed | Maximum fan speed | Minimum fan speed

| COOLING | FEATURES |
|---|---|
| 26/30 | 18/20 |
| **DESIGN** | **VALUE** |
| 24/30 | 16/20 |

**OVERALL SCORE**
**84%**

### VERDICT

If you're after a solid, good-looking large ATX case for less than £130, the 600C boasts lots of features and great cooling, as well as quiet operation.

PC Specialist recommends Windows Windows 10

# Performance without compromise

## Spectre Lite

- AMD FX-4300
- ASUS® M5A97 R2.0
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 950
- 1TB Hard Drive
- Corsair 350W PSU
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM £499*

## Gladius 900

- Intel® Core™ i5-6600K
- ASUS® Maximus VIII Hero
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 960
- 1TB Hard Drive
- Corsair 450W PSU
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM £899*

## Vitrum

- Intel® Core™ i5-6600K
- ASUS® Z170-E
- 16GB HyperX FURY RAM
- 4GB NVIDIA® GeForce® GTX 970
- 400GB Intel® 750 PCIe SSD
- 1TB Hard Drive
- **Windows 10**
- 3 Years Warranty

THIS SPEC FROM £1,199*

## Glacier

- OC Intel® Core™ i7-6700K
- ASUS® Maximus VIII Hero
- 16GB Corsair Vengeance RAM
- 6GB NVIDIA® GeForce™ GTX980Ti
- 400GB Intel® 750 PCIe SSD
- 2TB Hard Drive
- **Windows 10**
- 3 Years Warranty

THIS SPEC FROM £1,799*

## 14" Enigma VI

- Intel® Core™ M CPUs
- Intel Integrate Graphics
- Ultra thin: Just 15.6mm!
- Full HD IPS Screen
- Up to 7.5 Hours Battery
- Wireless as standard
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM £409*

## 15.6" Octane II

- 6th Gen Intel® Core™ CPUs
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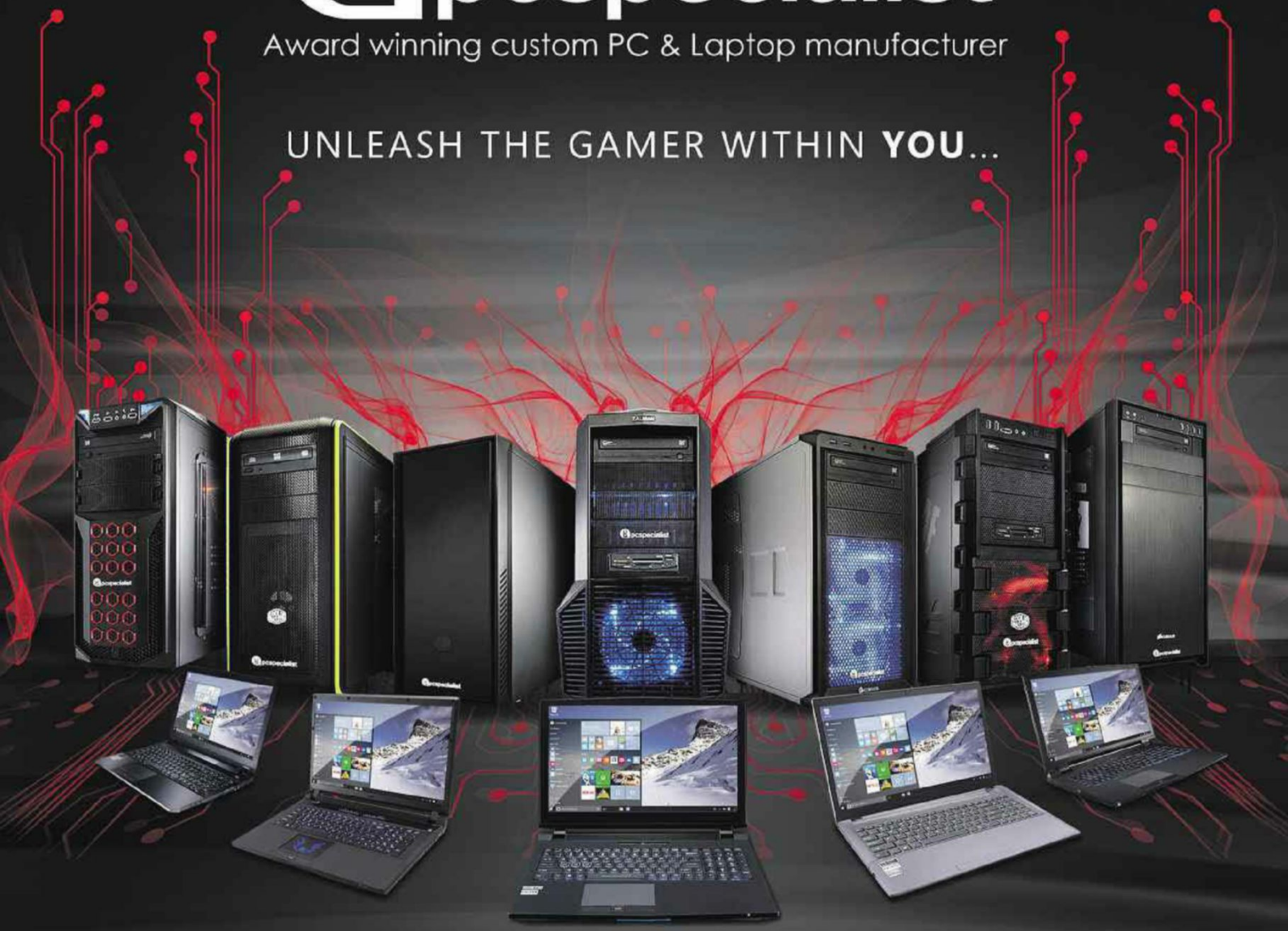

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35IN CURVED MONITOR

# BenQ XR3501 / £732 inc VAT

SUPPLIER www.scan.co.uk

The XR3501 is the latest addition to the exciting arena of curved gaming monitors, and BenQ has designed this panel with a tighter curvature than its rivals. The 35in XR3501 is built with a curvature of 2,000R, which easily beats the 3,800R measurement of the larger Asus ROG Swift PG348Q. In effect, this measurement means the BenQ's panel is a slice of a smaller circle – which means the XR3501 more effectively wraps around the user than the Asus. That tight curve is great for immersion in games, but it can be initially disarming; the curvature can be seen on horizontal lines more obviously than on other panels.

Interestingly, unlike many large, curved monitors, the BenQ doesn't have a 3,440 x 1,440 resolution, instead offering a 2,560 x 1,080 resolution. That choice is going to result in comparatively chunky pixel density, but also enables BenQ to offer a super-fast 144Hz refresh rate. Meanwhile, the XR3501's 8-bit VA screen can render 16.7 million colours, and will likely deliver excellent contrast and deep black levels.

The XR3501's 8-bit VA screen can render 16.7 million colours

It isn't in the same league as the aforementioned Asus screen's 10-bit IPS panel, which can effectively render just over one billion shades, but that's no surprise considering that it costs nearly £300 more than the BenQ.

The BenQ's lower price also means it doesn't support Nvidia's G-Sync tech, or FreeSync for that matter, so it won't be able to link GPU frames to the monitor's refresh rate to deliver butter-smooth gameplay. However, the XR3501 does fight back with 144Hz operation, which is as good as it gets without active sync tech, and it means the BenQ will be smoother than most monitors on the market in games.

Likewise, there aren't any USB ports or speakers, and the XR3501's stand isn't that versatile either – the screen tilts back and forth, but there's no height adjustment or side-to-side swivelling. At least the BenQ looks good and is easy to assemble. Its chrome-covered stand and smart exterior look good, and the build quality is sturdy. Attaching the base is simple, and navigating the OSD is easy, thanks to unfussy, solid buttons and obvious on-screen prompts.

In terms of image quality, VA panels often deliver huge contrast and deep black levels, and the BenQ's factory benchmarks didn't disappoint: the 340cd/m$^2$ brightness and 0.2cd/m$^2$ black levels combined for a 1,700:1 contrast level, which is far higher than that of the aforementioned Asus screen.

The BenQ wasn't as good at colour reproduction though. Its 6,999K temperature is comparatively cool and the average delta E of 4.09 lags behind the Asus' result of 1.74. The sRGB gamut coverage of 99.3 per cent is a decent result though.

We then calibrated the BenQ, toning the brightness down to a more palatable 150cd/m$^2$, and the XR3501 continued to impress at these settings. Its 1,666:1 contrast ratio and 0.09cd/m$^2$ black level remain excellent. The delta E improved to 1.06 too, although the colour temperature remained too cool at 7,153K.

This screen has several modes, but none of them is great. The two FPS modes make the colour temperature cooler and the black level worse, and the racing mode suffers similarly. Meanwhile, the Movie mode makes every factory benchmark result worse, and the Photo mode sees the colour temperature decline to 10,316K.

The BenQ's lesser budget is obvious when it comes to uniformity too. The XR3501's backlight dipped by up to 21 per cent along its top edge and 23 per cent across the middle – a long way short of the Asus' scores. The BenQ's tight curvature helps negate those issues, at least.

## Conclusion

The BenQ XR350's tight curve and 144Hz refresh rate make for immersive gaming, but the low resolution and lack of active sync support highlights the sacrifices you make when opting for a cheaper, curved gaming monitor. Also, while the XR3501 has great contrast and black levels, it falls down when it comes to colour accuracy and uniformity. The XR3501 is a reasonable curved gaming monitor if your budget won't go any further, but if you really want a large, curved gaming panel, you'll be much better off saving up more money for the more accomplished Asus PG348Q.

**MIKE JENNINGS**

| IMAGE | FEATURES | VALUE |
|---|---|---|
| 39/50 | 15/20 | 25/30 |

OVERALL SCORE **79%**

**VERDICT**

**Good design, great contrast and a fast refresh rate, but let down by a low resolution, no active sync and disappointing colour accuracy.**

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# Custom Kit

Paul Goodhead checks out the latest gadgets, gizmos and geek toys

## COOKING UTENSIL

### Star Wars Lightsaber BBQ Tongs / £25 inc VAT

Thought you'd seen every piece of Star Wars merchandise going? Think again. Yes, you can now flip your grilled goodies before they turn too far to the dark side with this lightsaber-themed set of tongs. Complete with electronic zummm zummm sound effects, and a red sheath for when the tongs aren't in use, they're just about the right side of knowingly corny to be fun. Thankfully, the sound effects can be turned off, so you can stop short of infuriating your guests before they've even been served a starter.

The build quality is middling, as you'd expect from a novelty item, and the themed handle is also little too big for most people to hold comfortably. However, anyone looking for a serious piece of kitchenware should be looking elsewhere anyway.

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**SUPPLIER** www.menkind.com

## HARD DISK CADDY

### ToughArmor MB991U3-1SB / £60 inc VAT

In the week that we've had our hands on the ToughArmor, we've subjected it to just about every drop, crush and impact test we can imagine, and it's still intact and functioning. Even so, we find it hard to call the caddy truly rugged, thanks to the numerous cooling vents cut into the otherwise protective exterior casing, which make it vulnerable to water and dust ingress.

You can drop the case from 6ft onto concrete without a problem, but drop it from an inch into a puddle and you'll be in trouble. It's a pity, as the enclosure was pretty quick with an SSD inside it, reading and writing at 271MB/sec and 119MB/sec respectively. For £60, it isn't cheap either. However, if you want your external storage to be drop-proof, the ToughArmor definitely lives up to its name.

●●●○○

**SUPPLIER** www.overclockers.co.uk

## BLUETOOTH SPEAKER

### Libratone Zipp / £219 inc VAT

Libratone designs its speakers to stand out, and the Zipp is available in numerous bright colours. The unit, which is around the size of a pint glass, looks great on a shelf or coffee table. Audio proved excellent, with the Zipp being more than capable of filling a large room with rich, balanced sound, and performance remained commendably consistent throughout the whole volume range.

The speaker is immensely flexible – it will regurgitate audio from a Bluetooth, USB or Wi-Fi connection, and is compatible with Airplay, DLNA and Spotify Direct. The companion app even lets you connect to multiple Zipp speakers, so you can push the same audio to several rooms, or set up different 'SoundSpaces', each with its own audio source. The cost of such a setup would be astronomical, but that won't prevent us from putting it on our dream wish list.

●●●●●

**SUPPLIER** www.libratone.com

## VALUABLES TRACKER

### Tile / £20 inc VAT

The Tile presents a pleasingly slick solution to a common problem – losing important objects. Attach a Tile to an object you value, pair it with your smartphone and you're set. Your phone tracks the item while it's near you (within Bluetooth range, specifically), noting the place and time it lost connection if you move away from it. Cleverly, you can mark items as lost in the app too. This mark automatically sets all other phones running the Tile app to look for your item, notifying you when and where a connection was made with your erstwhile tracker. Each Tile is a sealed weatherproof unit, however, so once the battery runs out (which Tile guarantees won't happen for at least a year), you'll need to purchase a new one, which leaves a rather bitter taste from an otherwise well thought-out product.

●●●●○

**SUPPLIER** www.firebox.com

## LIGHT STRIP

### Luminoodle / £30 inc VAT

The brilliantly named Luminoodle is the one of the most useful gadgets we never knew we needed. Little more than a weatherproof strip of USB-powered LEDs, it's a handy device when camping, working in poorly lit tight spaces (such as under a car) or just sitting out in the garden after dark. It's magnetic and includes myriad loops, ties and fixings, meaning you're able to stick it, wrap it or clip it just about anywhere. The £30 price includes a 4400mAh battery, which is good value for money, given that you can use the power pack to power other gear too. Our only concern is that, while the noodle is fully waterproof, the battery isn't, which limits the outdoors credentials a little.

●●●●○

**SUPPLIER** www.firebox.com

## USB SOUND CARD

### Sound BlasterX G1 / £40 inc VAT

With motherboard audio becoming increasingly sophisticated, sound card manufacturers are adapting. Behold the G1 from Creative, a USB sound card aimed at gamers. Operated via Creative's straightforward Acoustic Engine software, the G1 aims to tweak game audio to give the listener an advantage over their opponents. Scout mode, for example, picks out and boosts footstep sounds. A default profile can be saved to the card itself too, removing the need for software if you take the G1 on the road.

It's all very clever, but we found the gaming-specific settings overly intrusive, making audio feel unnatural and breaking our immersion. The G1 was, however, a boon on the move – movies on our cheap laptop worked well with its 7.1 emulation, and Creative's Crystalizer engine is good for music too, although these features are also available on cheaper Creative USB sound cards.

●●●○○

**SUPPLIER** www.creative.com

**Seen something worthy of appearing in Custom Kit? Send your suggestions to** paul_goodhead@dennis.co.uk

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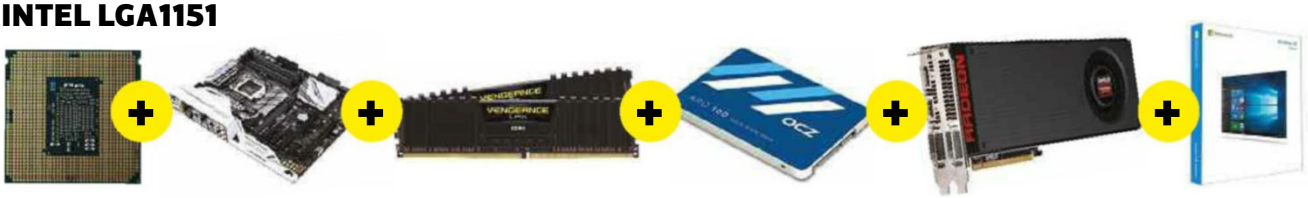
# How we test

Thorough testing and research is the key to evaluating whether a product is worth buying, and deciding whether or not there's a better alternative

## PROCESSORS

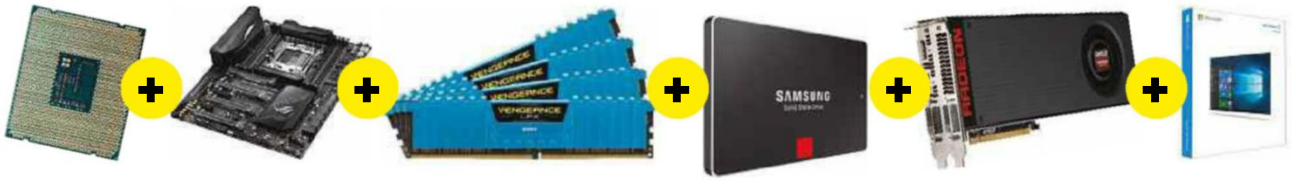
We judge CPUs on whether they offer sufficient speed for the price. Part of a CPU's speed score comes from how overclockable it is. Every type of CPU is tested in the same PC, so all results are directly comparable.

### INTEL LGA1151



Intel LGA1151 CPU | Asus Z170 Deluxe (ASRock Z170 Extreme4 for Core i3 6100 test) | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 240GB OCZ Arc 100 | AMD Radeon R9 390X | Windows 10 64-bit

### INTEL LGA2011-V3

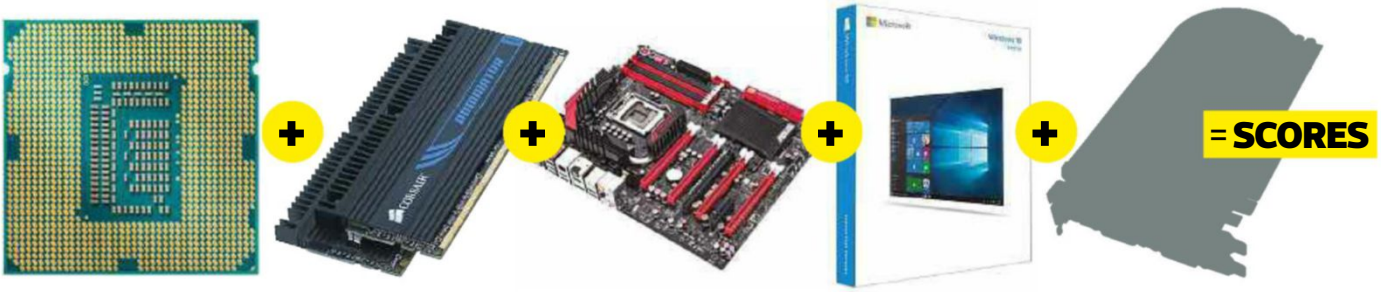


Intel LGA2011-v3 CPU | Asus Rampage V Extreme 10 Edition | 32GB Corsair Vengeance LPX 2666MHz DDR4 | Samsung SSD 850 Pro | AMD Radeon R9 390X | Windows 10 64-bit

**TESTS:** We use Custom PC RealBench 2015, Cinebench R11.5 and a variety of games. We also test the power draw of the test PC with the CPU installed. These tests reveal a broad range of performance characteristics, from image editing to gaming and video encoding to 3D rendering. We run all tests at stock speed and again when overclocked to its highest frequency.

## GRAPHICS CARDS

Graphics cards are mainly evaluated on how fast they are for their price. However, we also consider the efficacy and quietness of the cooler. Every graphics card is tested in the same PC, so all results are directly comparable.




4.2GHz Intel Core i5-3570K | 8GB Corsair Dominator 2400MHz DDR3 | Asus Maximus V Extreme | Windows 10 64-bit | The graphics card we're reviewing

## CUSTOM PC REALBENCH 2015

### INTEL REFERENCE

Intel Core i7-4790K | 16GB of Corsair 2400MHz DDR3 | 240GB OCZ 150 | Asus Maximus Gene VII | Nvidia GeForce GTX 780 3GB

### AMD REFERENCE

AMD A10-7850K | 8GB of Corsair 2133MHz DDR3 | 256GB Plextor M5 Pro | Asus A88X-Pro

Our benchmark suite, co-developed with Asus, simulates how people really use PCs – a higher score is better. You can download them from www.asus.com/campaign/Realbench

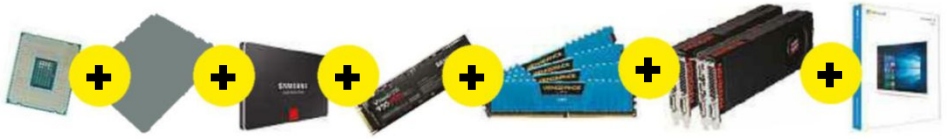
## MOTHERBOARDS

Motherboards are evaluated on everything from layout and features to overclockability and value for money. Every motherboard is tested with the same components, so all results are directly comparable.

### INTEL LGA1151

Intel Core i7-6700K | Motherboard on test | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 240GB OCZ Arc 100 | AMD Radeon R9 390X | Windows 10 64-bit

### INTEL LGA2011-V3



Intel Core i7-6850K | Motherboard on test | Samsung SSD 850 Pro | Samsung SSD 950 Pro | 32GB Corsair Vengeance LPX 3200MHz DDR4 | 2 x AMD Radeon R9 390X | Windows 10 64-bit

**TESTS:** We use Custom PC RealBench 2015 and Total War: Warhammer, and also test the speeds of the board's SATA and M.2 ports. We try to overclock every motherboard we review by testing for a maximum base clock as well as overclocking the CPU to its maximum air-cooled level. We run our tests at stock speed and with the CPU overclocked.

**TESTS:** By using the fast PC detailed on the left, we can be sure that any limitations are due to the graphics card on test, rather than being CPU limited. We test GTA V, Doom, Crysis 3, Fallout 4 and The Witcher III: Wild Hunt at their maximum detail settings, in their highest DirectX mode, at several resolutions. High-end cards should be able to sustain playable frame rates at 2,560 x 1,440, while 1,920 x 1,080 is more important for mid-range cards; we also test at 3,840 x 2,160 for 4K monitors, and try to overclock every graphics card we test to assess the performance impact.

## The Awards

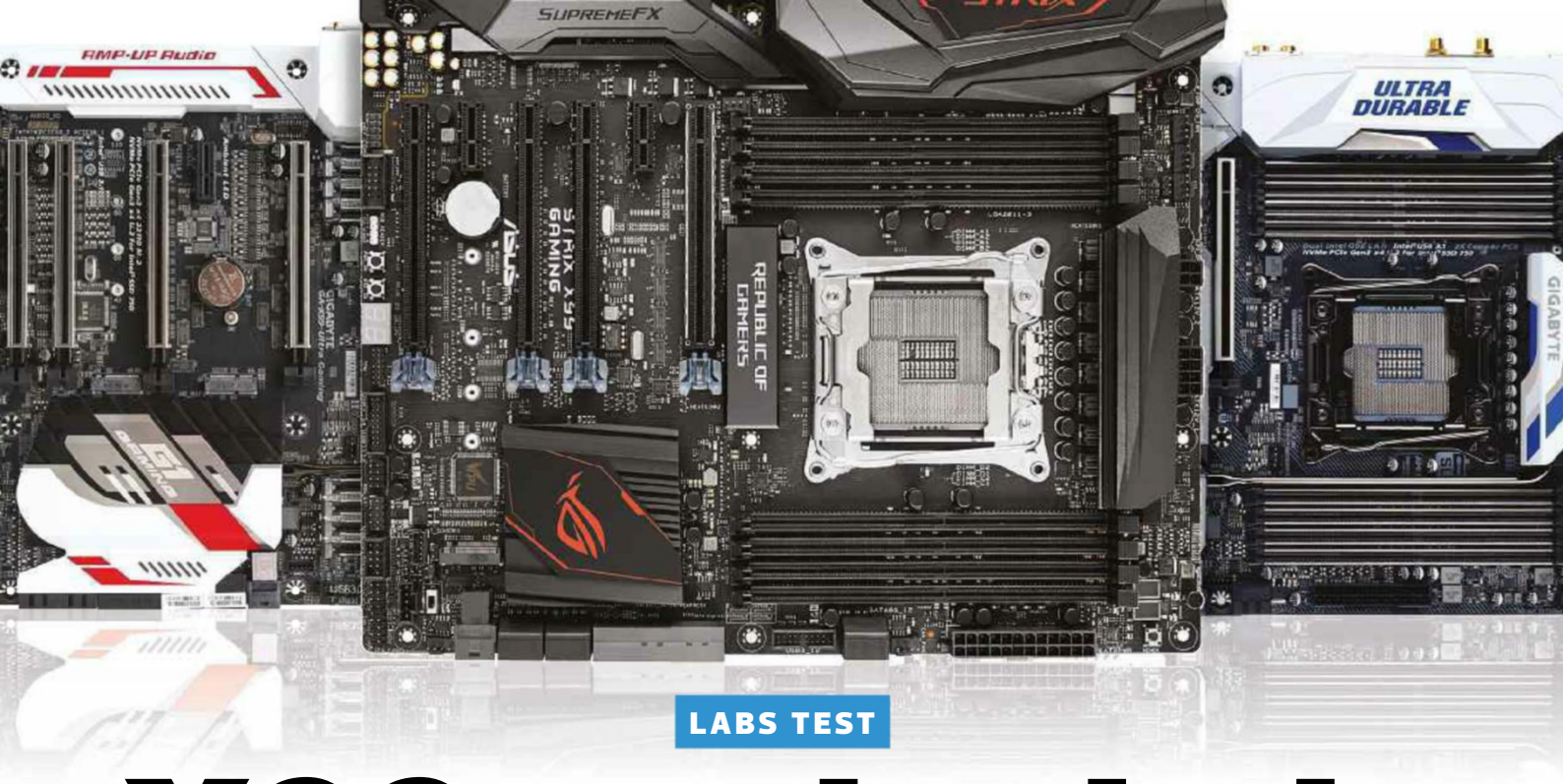
**EXTREME ULTRA**
Some products are gloriously over the top. These items of excellent overkill earn our Extreme Ultra award.

**PREMIUM GRADE**
Premium Grade products are utterly desirable – we'd eat nothing but beans until we could afford them.

**PROFESSIONAL**
Products worthy of the Professional award make you and your business appear even more awesome.

**APPROVED**
Approved products are those that do a great job for the money; they're the canny purchase for a great PC.

**CUSTOM KIT**
For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.




LABS TEST

# X99 motherlode

Antony Leather rounds up some of the latest X99 motherboards that have followed the Broadwell-E launch

## Featured this issue


Asus X99 Deluxe II / p41
Asus X99 Strix Gaming / p42
Gigabyte X99-Designare EX / p43
Gigabyte X99-Ultra Gaming / p44
Turbo Boost Max 3 / p45
MSI X99A Gaming Pro Carbon / p46
MSI X99A XPower Titanium / p48
Results graphs / p50


## How we test

We test each motherboard with a Core i7-6850K, 32GB of Corsair Vengeance LPX 3200MHz DDR4 RAM and two XFX Radeon R9 390X graphics cards in CrossFire configuration. We also use a Samsung 850 Pro SSD and 950 Pro M.2 SSD with CrystalDiskMark's 32-queue-depth storage test. To measure the performance of the on-board audio codec, we use RightMark Audio Analyzer using 24-bit/192KHz settings, with the line-out connected to the line-in to obtain noise and dynamic range levels.

We apply the optimised default settings and set the XMP profile in the EFI for stock speed tests, but touch no other settings, as we recommend for anyone setting up a new system. This process should set the correct memory speed and timings and ensure the board is set up for best stock speed performance. When overclocking, we find the maximum stable CPU frequency across all CPU cores and also identify the lowest stable voltage to get there. Our CPU usually maxes out at 4.4GHz with a vcore of approximately 1.35V. Above these settings, temperatures usually reach unsafe limits, but we always try to achieve higher frequencies and lower voltages. We also disable Intel SpeedStep, as doing so can give you a significant performance boost when overclocking, but with a small increase in idle power consumption.

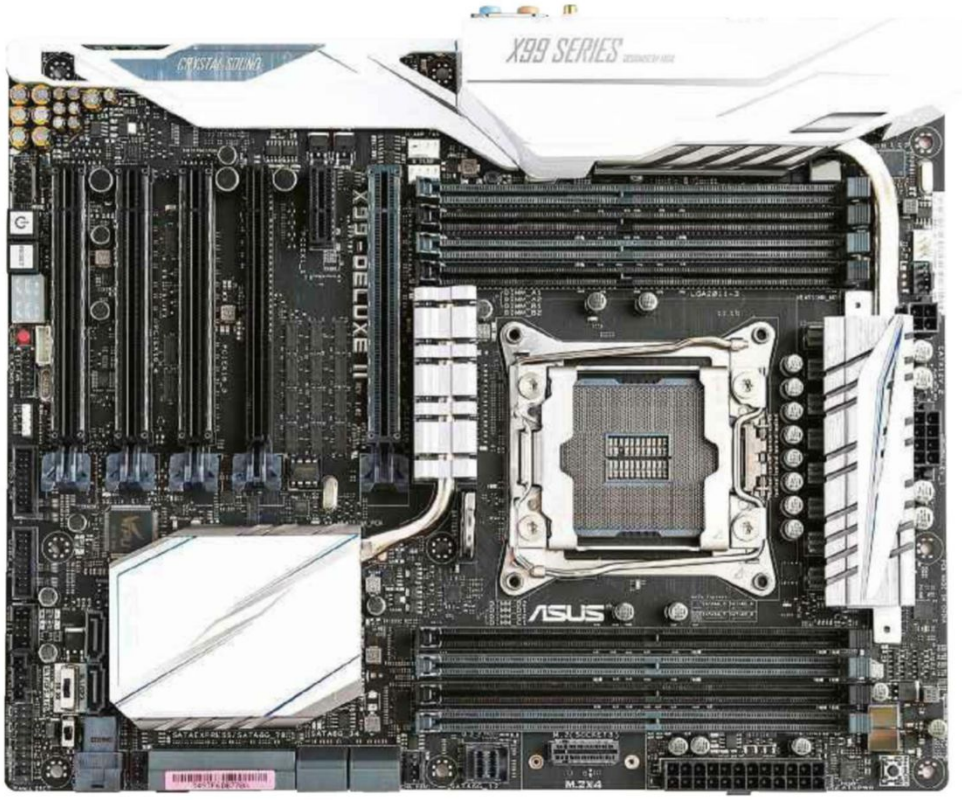
We use the latest version of RealBench 2015 (**www.asus.com/campaign/Realbench**), which tests single-threaded performance with the Gimp image editing suite, multi-threaded performance using the Handbrake open source video transcoder and heavy multi-tasking performance playing back full-screen HD video while conducting a video transcode. Each test produces an individual point score based on completion time and also outputs a weighted system score.

We also use Total War: Warhammer at 1,920 x 1,080 with Medium settings to limit any GPU bottlenecking, and use the built-in benchmark in the graphics settings section, which records the minimum and maximum frame rate. Finally, we record both idle and load power readings from the mains for the system as a whole using a power meter. The idle reading is taken at the desktop with no programs open, while the load result is taken using Prime95's smallfft test. We use a weighted calculation to work out the performance score using the results from the benchmarks, and use a similar calculation to work out the features and value scores. The scores are then added together to give a final score.

ELITE
NEW ENTRY
P66

# Asus X99 Deluxe II / £335 inc VAT

**SUPPLIER** www.scan.co.uk




We were massively impressed with the original X99 Deluxe when we looked at it back in 2014, where it picked up a Premium Grade award. Many of the original features are still here with the X99 Deluxe II, although many have been revamped and there are some additional ones too. To start, the board has received an RGB makeover, with a 4-pin RGB LED strip header at the base of the PCB, and the included Aura software can control third party LEDs via this header too.

In addition, the audio circuitry, PCI-E slot levers and PCH heatsink are also illuminated. The slot levers' lights change based on the GPU configuration you use. By toggling a switch beneath the PCH heatsink, the lights indicate the correct slots to use for 2-way, 3-way and 4-way GPU configurations for the best bandwidth. It's one of the few boards on test to officially support 4-way configurations using 40-lane CPUs such as the Core i7-6950X, with each slot receiving eight lanes. With 3-way setups, you'll get two 16x slots and one 8x slot, although the Gigabyte X99-Designare EX trumps the Deluxe in this area, giving three slots the full 16 lanes, thanks to its PEX8747 chip.

It's worth noting, though, that the Asus board's second slot for multi-GPU configurations shares bandwidth with one of the board's two U.2 ports and the M.2 port, with its bandwidth falling to eight lanes if you use them. Thankfully, there's another U.2 port that doesn't interfere unless you use more than two graphics cards. The two primary 16x PCI-E slots are double-spaced for better cooling with dual-slot graphics card coolers although, like a number of other boards on test, the top slot sits right next to the central heatsink, which makes removing your graphics card quite difficult.

> The two primary 16x PCI-E slots are double-spaced for better cooling

The X99 Deluxe II includes the full suite of overclocking tools and you also get a high amperage fan header and dedicated water-cooling pump header. Several USB 3.1 Type-A and Type-C ports are included too. The PCB is certainly very busy, but the only slight issue is that the M.2 port and one of the U.2 ports are vertically mounted to save space, which looks a little unsightly with cards installed. A big part of the price tag clearly goes towards the vast amount of extras too. A slot-in card provides additional fan headers, you can add a second M.2 slot courtesy of a PCI-E expansion card and there's a Thunderbolt 3 add-in card too.

Meanwhile, overclocking was easy, thanks to the excellent EFI and we're fairly sure 4.5GHz would have been achievable with water cooling and more time. However, 1.36V was needed to get our CPU to 4.4GHz. Overall, the Deluxe was one of the best-performing boards on test, with great stock-speed numbers and competitive overclocked results in addition to solid audio performance.

## Conclusion

The X99 Deluxe looks fantastic, has the biggest array of features on test and offers a superb base for multi-GPU systems and cutting-edge storage. There's a lot of excess, though, so you'll need to weigh up the benefits compared with the X99 Gaming Strix for your particular needs, while the Gigabyte X99 Designare EX has a little more pizzazz and bandwidth if you'll be using more than two graphics cards.

**PERFORMANCE** 32/35 **FEATURES** 33/35 **VALUE** 24/30

**OVERALL SCORE** 89%

## VERDICT

**The X99 Deluxe II ticks practically every box and then throws more features into the mix, and it's fast too, although it isn't cheap.**

### /SPECIFICATIONS

**Chipset** Intel X99

**CPU socket** Intel LGA2011-v3

**Memory support** 8 slots: max 128GB DDR3 (up to 3333MHz)

**Expansion slots** Five 16x PCI-E 3, one 1x PCI-E 2

**Sound** Realtek ALC1150

**Networking** Intel I218-V Gigabit LAN, Intel I211-AT Gigabyte LAN, 802.11ac Wi-Fi

**Overclocking** Base clock 80–300MHz, CPU multiplier 20–80x; max voltages: CPU 1.92V, RAM 1.9V

**Ports** 10 x SATA 6Gbps (Z170), 2 x SATA Express 6Gbps, 2 x M.2, 2 x U.2, 8 x USB 3, 5 x USB 3.1 Type-A, 2 x USB 3.1 Type-C, 6 x USB 2, 2 x LAN, 3 x surround audio out, line in, mic

**Dimensions (mm)** 305 x 244

# Asus Strix X99 Gaming / £253 inc VAT

SUPPLIER www.scan.co.uk

As if fairly extensive RGB lighting wasn't enough, Asus has gone one step further with the Strix X99 Gaming and included replacement badges for the I/O shroud and PCH heatsink. These badges come in orange, pink, silver and luminous green, and there's an RGB LED strip extension cable in the box too, with a 4-pin header on the PCB ready and waiting for it.

The lighting itself is fairly low-key on the motherboard, especially compared with the MSI X99A Gaming Pro Carbon (see p48), and the Strix X99 Gaming is fairly understated elsewhere too, although the lighting adds a good touch of zing and it's controlled using Windows software. Only the Strix's primary 16x PCI-E slot sports a metal shroud too; the MSI Gaming Pro Carbon's steel-clad PCI-E and DIMM slots undoubtedly give it the edge in terms of looks. However, the latter does cost £10 more and, unlike the MSI board, the Strix X99 Gaming has double-spaced primary and secondary 16x PCI-E slots. As a result, dual-slot, air-cooled graphics cards will at least get an inch or so clearance for better cooling in SLI or CrossFire setups, which could prevent thermal throttling.

As with the other X99 boards on test, the Strix X99 Gaming offers the full range of new storage standards, with ASMedia-powered USB 3.1 Type-A and Type-C ports, plus U.2 and M.2 ports, which share bandwidth. Unlike the MSI X99A Gaming Pro Carbon, the Strix also sports 802.11ac Wi-Fi and Bluetooth; however, while both boards have on-board power and reset buttons plus an LED POST code display, only the MSI X99A Gaming Pro Carbon has a clear-CMOS button.

> The lighting adds a touch of zing and it's controlled using Windows software

The Strix's PCB layout is generally excellent, though, and you get dedicated fan headers for water-cooling pumps and high-power fans. However, the illuminated heatsink in the centre makes removing graphics cards quite tricky. Meanwhile, the EFI has a familiar ROG feel with its usual features and excellent layout. Asus' fan control suite is second to none, and even allows you to switch off case fans under certain temperatures for lower noise.

Overclocking with the Strix saw us reach our CPU's maximum frequency of 4.4GHz with just a 1.34V vcore. However, it still had comparatively high idle and load power consumption at these settings, with only the MSI Gaming Pro Carbon producing similar figures.

Performance at stock and overclocked speeds were excellent, with the stock-speed results particularly potent thanks to the CPU regularly Turbo Boosting to 4GHz – a feat that some other boards couldn't manage. Both MSI boards had a slight advantage in some of the Realbench tests once they were overclocked, but overall, the Strix's performance was very similar, with no areas of concern and significant gains once it was overclocked. The audio performance was excellent too, although the results from all boards using Realtek's ALC1150 codec were very similar.

## Conclusion

If you can't afford the X99 Deluxe II, or don't need its various additional features, the Strix X99 Gaming is our X99 board of choice. It offers great customisation, it's fast at stock and overclocked speeds, it sports 802.11ac Wi-Fi and it has Asus' huge suite of software and EFI features too. Best of all, it only costs £253 inc VAT, and while it may not come with buckets of fancy features, it has all the important ones.

PERFORMANCE 32/35 | FEATURES 26/35 | VALUE 28/30

OVERALL SCORE 86%

### VERDICT

**Whether you're building a single or multi-GPU system, the Strix X99 Gaming offers decent performance, a solid feature set and great customisation.**

### SPECIFICATIONS

**Chipset** Intel X99
**CPU socket** Intel LGA2011-v3
**Memory support** 8 slots: max 128GB DDR3 (up to 3466MHz)
**Expansion slots** Four 16x PCI-E 3, two 1x PCI-E 2
**Sound** Realtek ALC1150
**Networking** Intel I218-V Gigabit LAN, 802.11ac Wi-Fi
**Overclocking** Base clock 80–300MHz, CPU multiplier 12–80x; max voltages: CPU 1.92V, RAM 1.9V
**Ports** 10 x SATA 6Gbps (Z170), 2 x SATA Express 6Gbps, 1 x M.2, 1 x U.2, 8 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 2 x USB 2, 1 x LAN, 3 x surround audio out, line in, mic
**Dimensions (mm)** 305 x 244

# Gigabyte X99-Designare EX / £390 inc VAT

**SUPPLIER** www.overclockers.co.uk

As motherboards move beyond the realms of mere 2-way GPU setups, they usually need to call in reinforcements in the form of PCI-E switches that increase the number lanes and bandwidth available. The inclusion of a PEX 8747 PCI-E switch is one reason why the Gigabyte X99-Designare costs nearly £400, and the board's trump card is that it can give each card 16 lanes of bandwidth in a 3-way setup, if a 40-lane CPU is used. In addition, Gigabyte is waiting for Intel to certify Thunderbolt 3 on its latest range of motherboards equipped with Alpine Ridge controllers, including the X99-Designare. When this happens, the board will include both a DisplayPort connector and USB 3.1 Type-C socket for high bandwidth communication.

There are also two U.2 ports and a single M.2 port, which share bandwidth with various PCI-E slots. However, only one of the U.2 ports interferes with multi-GPU setups if it's used, reducing the second 16x PCI-E slot to eight lanes, while using the M.2 port does the same to the third 16x PCI-E slot. Also, use of the other U.2 port will require a 40-lane CPU.

Neither of Gigabyte's offerings in this test have on-board overclocking and testing tools, but the X99-Designare does have fantastic RGB LED lighting, which shines through various plastic and metal shrouds. You get a 4-pin header for third-party RGB LED strips and a 40cm extension cable.

All the slots, including the DIMM slots, are also covered in steel shrouds – the end result looks rather racy.

The PCB is partly covered in a metal shroud, which hides the unsightly 802.11ac Wi-Fi module. However, it also covers the M.2 slot, and you'll need to remove your graphics card in order to remove the shroud, which makes accessing an SSD here a little awkward. Gigabyte has also moved the primary CPU fan header to the bottom right of the CPU socket, although this location could make hiding cables a little easier. You also get two headers that are designed to power water cooling pumps.

Meanwhile, Gigabyte's refreshed EFIs improve on their recent predecessors, with a superior fan control suite, but the interface still isn't quite able to topple other manufacturers' efforts. Where Gigabyte does come out on top is with its EasyTune overclocking software. It's simple to use from within Windows, has none of the lag or stability issues we've seen with MSI's equivalent and it's less cluttered than Asus' AI Suite too. We had no issues getting with getting our CPU to 4.4GHz using a vcore of 1.35V.

> The fantastic RGB LED lighting shines through various plastic and metal shrouds

We did spot a fairly high idle power draw of 148W at stock speed, but otherwise performance was good. Both Gigabyte boards boosted nearly as aggressively as the Asus pair, which gave them a small advantage over the MSI boards at stock speed. The X99-Designare was the better performing of the two, all but matching the MSI and Asus boards overall, apart from a slight slip in the multi-tasking test and in the game test at stock speed. Audio performance was right up with the best on test too.

## Conclusion

The X99-Designare is ultimately an extreme motherboard with a price to match. It has a good design and decent performance, but it's also a niche product that only offers advantages for people installing more than two graphics cards – a market that will likely shrink following Nvidia's lack of support for 3-way and 4-way SLI (see p10). It looks snazzier than the Asus X99 Deluxe II, but it also costs £60 more and lacks some of the Deluxe's handy features.

| PERFORMANCE | FEATURES | VALUE | OVERALL SCORE |
|---|---|---|---|
| 31/35 | 28/35 | 19/30 | 78% |

### VERDICT

**The X99-Designare will only appeal to a niche of enthusiasts who want more than two GPUs. Otherwise, the Asus X99 Deluxe II is a better buy.**

### /SPECIFICATIONS

**Chipset** Intel X99

**CPU socket** Intel LGA2011-v3

**Memory support** 8 slots: max 128GB DDR3 (up to 3600MHz)

**Expansion slots** Five 16x PCI-E 3, one 1x PCI-E 2

**Sound** Realtek ALC1150

**Networking** 2 x Intel Gigabit LAN, 802.11ac Wi-Fi

**Overclocking** Base clock 80-266MHz, CPU multiplier 20-80x; max voltages: CPU 1.7V, RAM 2V

**Ports** 10 x SATA 6Gbps (Z170), 2 x SATA Express 6Gbps, 1 x M.2, 2 x U.2, 9 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 2 x USB 2, 2 x LAN, 3 x surround audio out, line in, mic

**Dimensions (mm)** 305 x 244

# Gigabyte X99-Ultra Gaming / £250 inc VAT

**SUPPLIER** www.cclonline.com

The most lavishly illuminated motherboard this month has to be Gigabyte's X99-Ultra Gaming. It not only sports an RGB LED header and extension cable, but the VRMs, PCH heatsink, audio circuitry and I/O shield are all lit with RGB LEDs, and Gigabyte has even installed RGB LEDs between the DIMM slots too. Acrylic strips in this location catch the light at each end and the result would put most Christmas trees to shame. All the lighting can be tweaked to match practically any colour, and you can set flashing, pulse and beat modes too.

The X99-Ultra Gaming is also the cheapest board on test, although there's only a £3 difference compared with the Asus X99 Strix Gaming. However, the Gigabyte is a little lacking in a number of areas. It's devoid of any on-board overclocking and testing tools, for example, while the Asus X99 Strix Gaming has power and reset buttons as well as an LED POST code display. Also, while the Gigabyte board includes an M.2 port specifically for Wi-Fi modules, it fails to offer Wi-Fi out of the box, whereas the Asus board includes it.

It's tit for tat with the rest of the specifications, though. The Gigabyte board sports Intel-controlled USB 3.1 ports whereas the Asus board uses an ASMedia controller. The Asus board has a better EFI and larger set of software features, but the X99-Ultra Gaming sports slicker Windows overclocking software. The PCB layout of the X99-Ultra Gaming is arguably a little better than the X99 Strix Gaming, with no mid-board heatsink getting in the way of graphics card installation. What's more, the Gigabyte's metal shroud stretches from the PCH heatsink to the SATA ports, adding further zest to an already good-looking board.

> Cooling is aided by a heatpipe connecting the PCH and VRM heatsinks

If you're gunning for a multi-GPU system, the X99-Ultra Gaming also offers additional power for the PCI-E slots as well as double-spaced first and second 16x slots to improve cooling for graphics cards with dual-slot coolers. Cooling is aided by a heatpipe connecting the PCH and VRM heatsinks too – a feature the Asus board lacks.

It was blow for blow in the overclocking stakes too, with the X99-Ultra Gaming needing the same 1.34V as the X99 Strix Gaming to get our CPU to 4.4GHz, although the Gigabyte board consumed noticeably less power when overclocked.

In terms of performance, the Gigabyte's score of 51,620 in our Gimp image editing test at stock speed was the top result, but it sadly lacked the grunt needed to get to the top of the graphs in most other tests, losing a few points here and there. However, its audio performance was excellent and it had no problem pushing our Samsung 950 Pro SSD to its limits with a 2,300MB/sec read speed using the M.2 port.

## Conclusion

If good looks are a top priority, perhaps for a modding project, the Gigabyte X99-Ultra Gaming is one of the best illuminated boards we've seen. The Asus X99 Strix Gaming offers replacement stickers for its I/O shroud and PCH heatsink, but its lighting is no way near as extensive.

The only downside for this Gigabyte board's appearance is that it uses a white and red colour scheme, which might clash with your own system colours even if the lighting offers the full RGB spectrum. More importantly, though, the X99-Ultra Gaming lacks a few important features; when combined with slightly lacklustre performance overall, this means that the Asus X99 Strix Gaming is a better buy in this price league.

| PERFORMANCE | FEATURES | VALUE | OVERALL SCORE |
|---|---|---|---|
| 29/35 | 25/35 | 26/30 | 80% |

**VERDICT**

**One of the most extensive lighting systems we've seen, but it lacks a few key enthusiast features.**

**/SPECIFICATIONS**

**Chipset** Intel X99

**CPU socket** Intel LGA2011-v3

**Memory support** 8 slots: max 128GB DDR3 (up to 3600MHz)

**Expansion slots** four 16x PCI-E 3, one 1x PCI-E 2

**Sound** Realtek ALC1150

**Networking** 1 x Intel Gigabit LAN, 1 x Killer Gigabit LAN

**Overclocking** Base clock 80–300MHz, CPU multiplier 20–80x; max voltages: CPU 1.7V, RAM 2V

**Ports** 10 x SATA 6Gbps (Z170), 1 x SATA Express 6Gbps, 2 x M.2, 1 x U.2, 10 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 2 x USB 2, 2 x LAN, 3 x surround audio out, line in, mic

**Dimensions (mm)** 305 x 244

# Turbo Boost Max 3

Intel has introduced a new feature with its latest CPUs – Turbo Boost Max 3 (TBM3). It sits alongside, rather than replacing, Turbo Boost 2.0, which simply increases core clock speeds up to a certain frequency based on the load. For example, the Intel Core i7-6850K we've used in this month's motherboard Labs test has a base frequency of 3.6GHz, but Turbo Boost can increase this clock speed under certain conditions.

**We had to set the CPU core ratio to 'By Specific Core' in our Asus EFI in order to identify the best core**

## Finding the best core

TBM3 is slightly more involved. Individual CPU cores aren't created equal when it comes to voltages and frequencies. Each core will be unique, will run at different temperatures and will be located in a different area of the CPU. As a result, individually overclocking each core will see a wide range of maximum frequencies, each core will require a different voltage to reach a specific frequency.

Helpfully, TBM3 identifies the core that's the best overclocker. This good egg is singled out in a new driver and software package that you must install with the new 6000-series CPUs.

It's also shown in the EFI of many new motherboards with an asterisk next to it in the overclocking section.

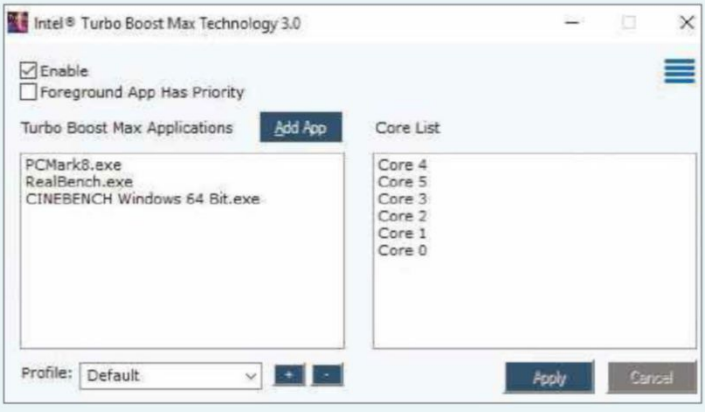
The software allows you to assign programs to this core, and they will then benefit from TBM3's ability to push the core's frequency beyond the maximum Turbo Boost frequency. This system can potentially allow for CPUs with six or more cores to regain ground lost in lightly threaded or single-threaded applications when compared with CPUs with faster clock speeds but fewer cores, such as Intel's current Skylake chips.

It all sounds good in practice, but TBM3 doesn't quite work as smoothly as you might expect. We've noticed quite a bit of variation in the performance it can offer, depending on the motherboard you're using. For example, as we've already mentioned elsewhere in this Labs test, Asus has programmed its boards to increase the Turbo frequency higher than Intel's rating with many Broadwell-E CPUs, which can cancel out some of the benefit of TBM3, as well as increasing power draw.

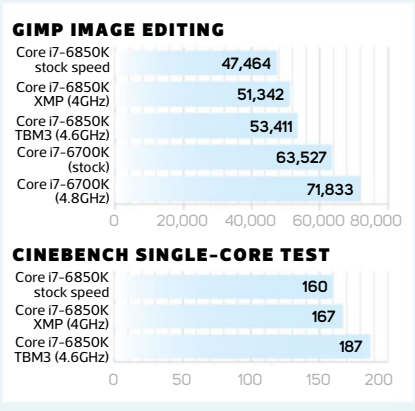
Intel's software listed Core 4 as the best core in our sample, and on the left of the interface you can add applications that will be assigned to this core – much like setting the affinity in Task Manager. The difference here is that the CPU core is overclocked and the program thread shunted onto that single faster core automatically. You can also force foreground programs to use the core instead. Sadly, though, this process didn't work automatically. We needed to set the CPU core ratio to 'By Specific Core' in our Asus EFI in order to identify the best core, and then type in the multiplier we wanted to use. The process felt a lot like manual overclocking - we assumed TBM3 would just require a Windows program to function.

However, as you can see from the results, there are still gains to be had, with the score from our mainly single-threaded Gimp image editing test rising from 47,464 to 53,411. Cinebench's single-core test rose from 160 to 187 too, with our single core flying along at 4.6GHz – 200MHz faster than we can achieve with a standard overclock. However, the way in which TBM3 works seems to depend on how the motherboard is configured and we've heard reports of the feature being disabled by default too, which is a shame, as it's potentially very useful.

Another issue is that many lightly threaded applications make use of more than one core, even if they're mainly single-threaded. As a result, while one of our CPU's cores ran at 4.6GHz, the rest of the cores still ran much slower, so the CPU still wasn't able to keep up with a quad-core Core i7-6700K in this test.




**Intel's Turbo Max 3 software – you can add applications that will be assigned to the overclocked core on the left**



# MSI X99A Gaming Pro Carbon / £263 inc VAT

SUPPLIER www.box.co.uk

If there was a motherboard that epitomises the focus on RGB lighting this month, it's MSI's X99A Gaming Pro Carbon. The PCB is littered with LEDs, which are spread across see-through sections of the isolated audio circuitry around the VRMs and in a large logo above the I/O shroud too.

In addition, the board includes a universal 4-pin RGB LED header as well as two extension cables with different lengths if you want use a third-party LED strip. Even without an extra strip, though, most of the PCB appears to glow and, thanks to the otherwise black PCB and features, it would be easy to use the Pro Carbon's LED lighting system to colour-match it to the rest of your system.

It's good to see all this lighting on a board that only costs £13 more than the cheapest board on test, and this board offers much more besides RGB lighting too.

You get the full complement of on-board overclocking and testing buttons and displays on the PCB, which are sadly lacking from Gigabyte's boards on test this month. Meanwhile, all the 16x PCI-E slots are covered in steel, which MSI claims will strengthen them and protects against interference, but they also look quite funky.

The PCB is certainly busy, but unlike a number of other boards on test, the Pro Carbon allows easy access to the primary 16x PCI-E slot lever. However, there's one major issue with the PCB layout, which is that the primary two 16x PCI-E slots you need to use for 2-way SLI and CrossFire setups aren't double-spaced. As a result, if your top card has a dual-slot GPU cooler, it will sit right next to a card in the second slot, hampering airflow. As such, Z99A Gaming Pro Carbon isn't ideal for air-cooled SLI or CrossFire systems, although it can at least dish out the full 16 lanes to both slots if you use a 40-lane CPU.

> You get the full complement of overclocking and testing buttons

As you'd expect from a modern X99 board, the Pro Carbon includes all the latest storage and connection options, such as USB 3.1 Type A and Type-C ports, with one of the latter on the PCB for compatible case front panels too, along with single U.2 and M.2 connectors. You can use either of the U.2 or M.2 ports alongside up to 2-way GPU setups without any loss of bandwidth, but you can't use both these storage ports together at the same time.

Overclocking proved fairly fruitful in our benchmarks, and was also an easy job, thanks to MSI's excellent EFI, although MSI's Windows-based overclocking utility was laggy and sometimes unstable. The Pro Carbon reached our CPU's maximum stable overclock of 4.4GHz, although it did need a vcore of 1.38V to get there – the highest voltage on test, which meant this board had the highest idle and load power draw once overclocked too. MSI's boards also Turbo boosted to a lower frequency than Asus' boards, which did see them at a disadvantage in some of the stock speed benchmarks, but the storage and audio results were excellent.

## Conclusion

Apart from the cramped PCI-E slots, which could lead to overheating on air-cooled 2-way GPU setups, the MSI Z99A Gaming Pro Carbon is decent board that also offers great lighting options. However, in this price league, Asus' Strix X99 Gaming offers a few more features and a superior layout, especially if you'll be opting for SLI or CrossFire.

| PERFORMANCE | FEATURES | VALUE | OVERALL SCORE |
|---|---|---|---|
| 31/35 | 25/35 | 25/30 | 81% |

### VERDICT

**Plenty of RGB lighting and on-board overclocking features, but in this price league, Asus' Strix X99 Gaming offers a superior layout.**

### / SPECIFICATIONS

**Chipset** Intel X99

**CPU socket** Intel LGA2011-v3

**Memory support** 8 slots: max 128GB DDR3 (up to 3466MHz)

**Expansion slots** Four 16x PCI-E 3, two 1x PCI-E 2

**Sound** Realtek ALC1150

**Networking** Intel I218-V Gigabit LAN

**Overclocking** Base clock 90–300MHz, CPU multiplier 20–80x; max voltages: CPU 2.1V, RAM 2V

**Ports** 10 x SATA 6Gbps (Z170), 1 x SATA Express 6Gbps, 1 x M.2, 1 x U.2, 9 x USB 3, 1 x USB 3.1 Type-A, 2 x USB 3.1 Type-C, 8 x USB 2, 1 x LAN, 3 x surround audio out, line in, mic

**Dimensions (mm)** 305 x 244

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## Available Now!

# MSI X99A XPower Gaming Titanium / £329 inc VAT

SUPPLIER www.scan.co.uk

While every other board on test has seemingly had most of its aesthetics budget ploughed in to RGB lighting, MSI's X99A XPower Gaming Titanium instead focuses on the PCB itself, which has received a metallic silver coating. Combined with steel shrouds covering its eight DIMM slots and five 16x PCI-E slots, plus its similarly coloured heatsink and I/O panel shrouds, the X99A XPower Gaming Titanium is an achingly good-looking board before you even power it up.

Thankfully, lighting isn't completely omitted either, as the dragon logo on the PCH heatsink lights up. There's a standard 4-pin RGB LED header on the PCB too, and MSI has included an extension cable for LED strips in the box. The black and silver colour scheme is also neutral enough to enable you to colour-match the rest of your hardware easily.

MSI has packed so much onto the PCB that it's had to stretch its width to 272mm. It's made very good use of the extra space as well, as the PCB has one of the best layouts on test. There's one fly in the ointment, which is that the central heatsink obstructs the primary PCI-E slot lever, as with several other boards this month.

Otherwise, though, the design is sublime. MSI has even triple-spaced the primary and secondary 16x PCI-E slots so that 2-way CrossFire or SLI setups with dual-slot coolers will have plenty of room for their graphics cards to breathe. Unfortunately, though, a small diagram printed onto the PCB indicating the correct slots to use for multi-GPU setups is obscured by the PCH heatsink, which is a bit of an oversight.

There are also additional power connectors for the CPU and graphics cards and, as with most other boards on test, there's a dedicated water-cooling pump header as well as a generous count of six other 4-pin fan headers. Like its cheaper sibling, the X99A XPower Gaming Titanium sports a dual BIOS switch too, which is handy for benchmarking, plus you get on board power and reset buttons, an LED POST code display and a clear-CMOS button.

In addition, there are buttons for adjusting the base clock and multiplier without the need to delve into the EFI. There's also a Game Boost knob that can automatically overclock Haswell-E and Broadwell-E CPUs. With voltage check points and a Slow Mode button, this board clearly isn't adverse to some extreme overclocking either.

> MSI packed so much onto the PCB that it had to stretch its width to 272mm

The X99A XPower Gaming Titanium has an excellent EFI too, with a handy fan control function, although it isn't quite as capable as Asus' efforts. However, the EFI is just as clear and well thought-out. We had no problems reaching our CPU's maximum frequency of 4.4GHz, with a fairly standard 1.36V needed, and it also managed the lowest overclocked idle and second lowest load power draw on test. At stock speed, it lagged behind the competition in most of our performance tests, but it posted some of the fasted results when it was overclocked. On the downside, its audio performance was comparatively mediocre.

## Conclusion

The MSI X99A XPower Gaming Titanium is a superb motherboard that's just at home with air-cooled SLI or CrossFire rigs as it is with water-cooled or even liquid nitrogen-cooled hardware. It has all the features an overclocking enthusiast would need and it looks fantastic. Only the mediocre audio performance lets it down. The feature-laden Asus X99 Deluxe II is our all-round favourite in this price league, but if overclocking and graphics card spacing are top priorities for you, the MSI X99A XPower Gaming Titanium looks great and is well designed.

| PERFORMANCE | FEATURES | VALUE | OVERALL SCORE |
|---|---|---|---|
| 32/35 | 30/35 | 23/30 | 85% |

### VERDICT

**One of the best-looking boards we've seen, and with a decent feature set and design to match, although it's pricey and its audio performance could be better.**

### /SPECIFICATIONS

**Chipset** Intel X99
**CPU socket** Intel LGA2011-v3
**Memory support** 8 slots: max 128GB DDR3 (up to 3466MHz)
**Expansion slots** Five 16x PCI-E 3, one 1x PCI-E 2
**Sound** Realtek ALC1150
**Networking** 1x Intel I218-V Gigabit LAN, 802.11ac Wi-Fi
**Overclocking** Base clock 80–300MHz, CPU multiplier 12–80x; max voltages: CPU 1.92V, RAM 1.9V
**Ports** 10 x SATA 6Gbps (Z170), 1 x SATA Express 6Gbps, 1 x M.2, 1 x U.2, 11 x USB 3, 1 x USB 3.1 Type-A, 7 x USB 3.1 Type-C, 2 x USB 2, 1 x LAN, 3 x surround audio out, line in, mic
**Dimensions (mm)** 305 x 272

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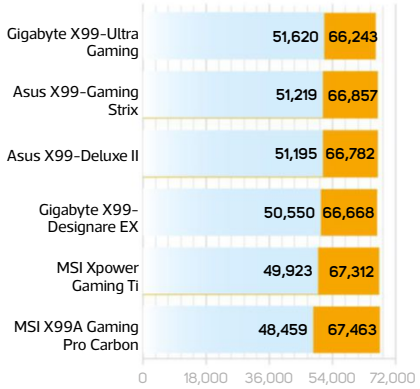
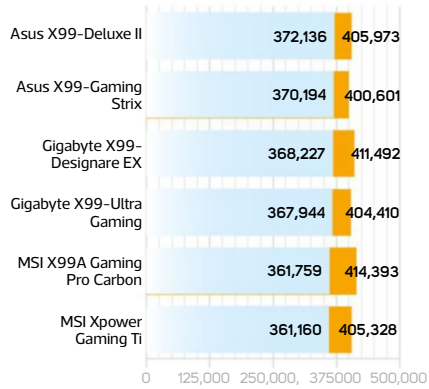
## BENCHMARK RESULTS

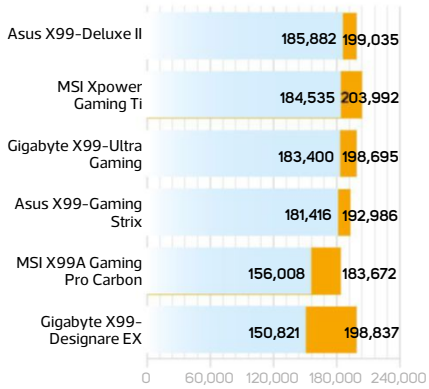
### GIMP IMAGE EDITING



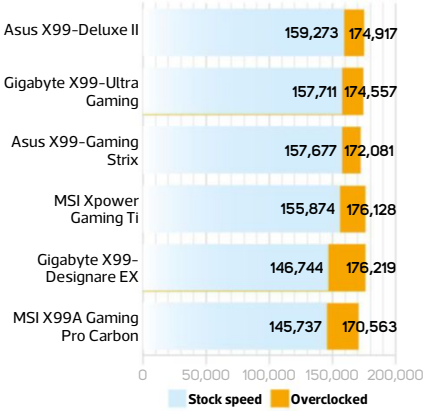

### HANDBRAKE H.264 VIDEO ENCODING




### HEAVY MULTI-TASKING

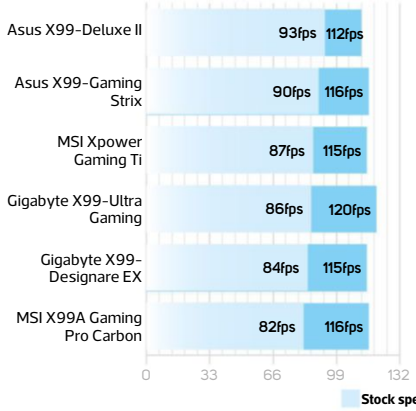



### SYSTEM SCORE



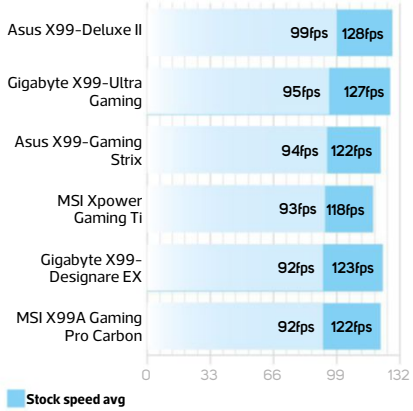

### TOTAL WAR: WARHAMMER (STOCK SPEED)

1,920 x 1,080, Medium settings



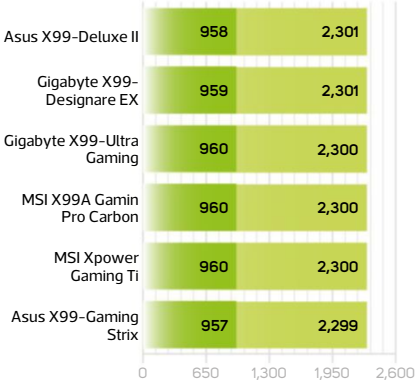

### TOTAL WAR: WARHAMMER (OVERCLOCKED)

1,920 x 1,080, Medium settings



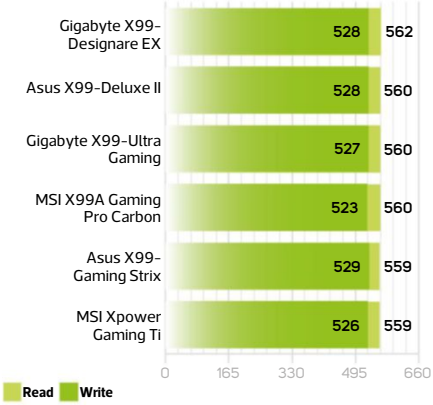

### M.2 SPEED (MB/SEC)

CrysalDiskmark 32-queue depth



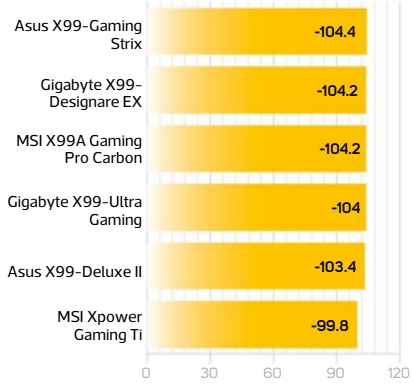

### SATA 6GBPS SPEED (MB/SEC)

CrysalDiskmark 32-queue depth



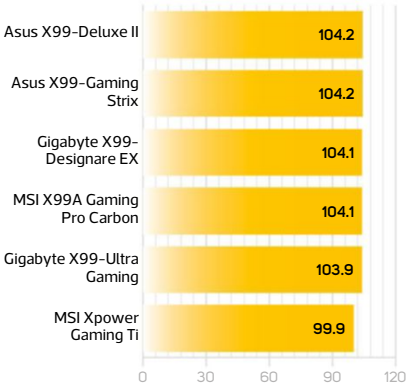

### NOISE LEVEL (DBA)

RightMark Audio Analyzer 24-bit/192KHz

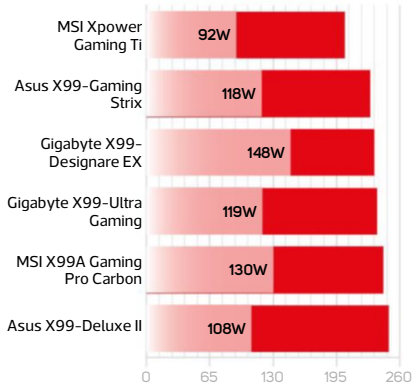



### DYNAMIC RANGE (DBA)

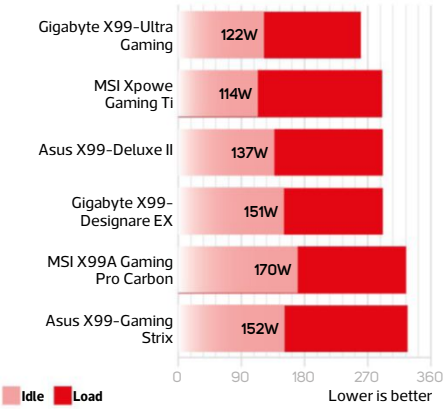
RightMark Audio Analyzer 24-bit/192KHz




### TOTAL SYSTEM POWER CONSUMPTION (STOCK SPEED)




### TOTAL SYSTEM POWER CONSUMPTION (OVERCLOCKED)



# From Apple to Zeiss, and everything in between

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Whether you're an IT professional or a first time buyer, Dennis technology has a magazine for you, all of which are written and produced by expert editorial teams. We cover the whole spectrum of technology news, reviews and features.

# Full 1080

We gave six of the UK's top system builders a brief to build a GeForce GTX 1080 PC, resulting in a variety of systems, costing from £1,722 to £4,100, and encompassing single and dual-GPU systems, and even an all-in-one PC. Mike Jennings puts each machine through its paces to find out which ones are worth your cash

## Featured this issue


| | |
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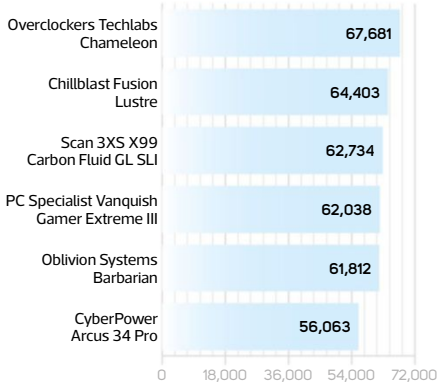
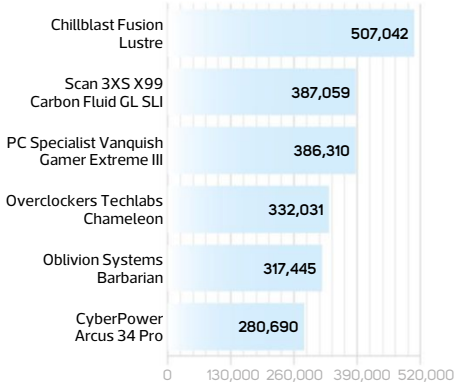
| Chillblast Fusion Lustre / p54 | Overclockers Techlabs Chameleon / p60 |
| CyberPower Arcus 34 Pro / p56 | PC Specialist Vanquish Gamer Extreme III / p62 |
| Oblivion Systems Barbarian / p58 | Scan 3XS X99 Carbon Fluid GL SLI / p64 |
| Results graphs / p53 | |

## CUSTOM PC REALBENCH 2015

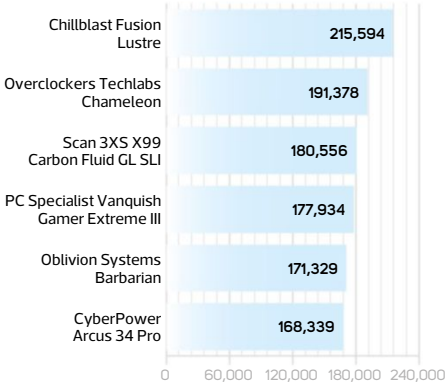
### GIMP IMAGE EDITING



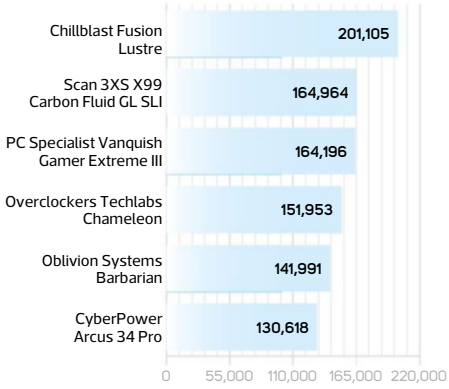

### HANDBRAKE H.264 VIDEO ENCODING



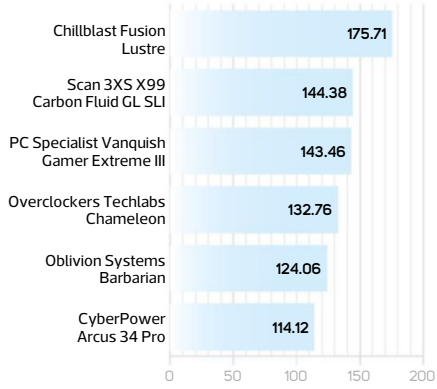

### HEAVY MULTI-TASKING




### SYSTEM SCORE



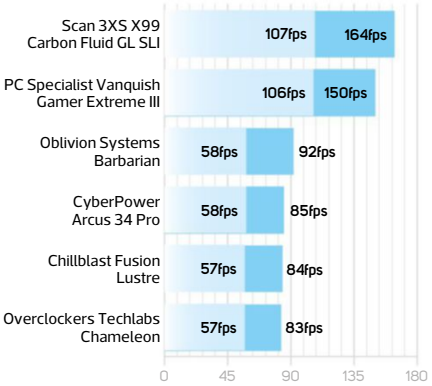

### INTEL REFERENCE (%)




## GAMES

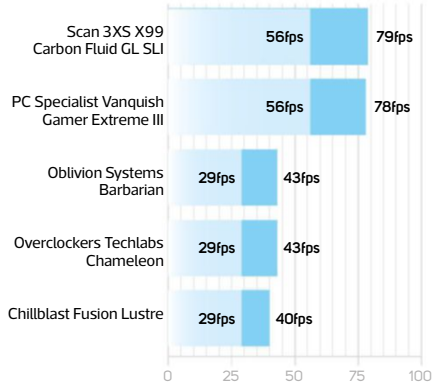
### CRYSIS 3

2,560 X 1,440 very high detail, 0X AA



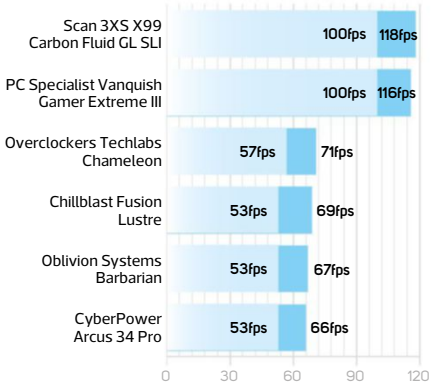

### CRYSIS 3

3,840 x 2,160 Very High Detail, 0x AA



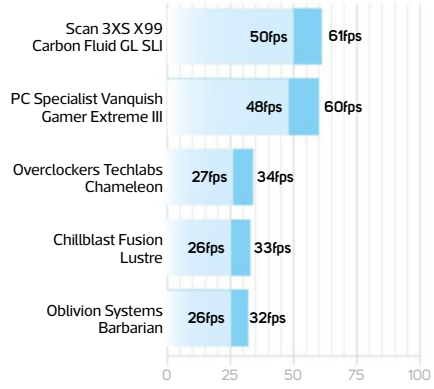

### FALLOUT 4

2,560 x 1,440, Ultra Detail, TAA



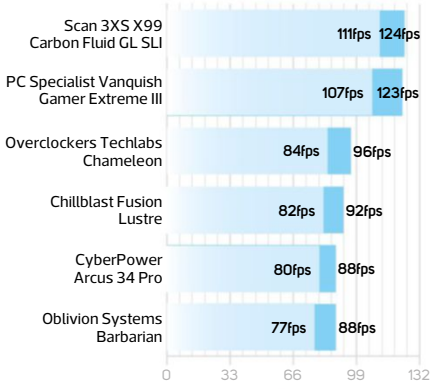

### FALLOUT 4

3,840 x 2,160, Ultra Detail, TAA



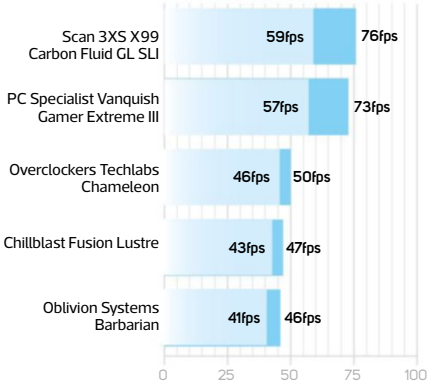

### THE WITCHER 3: WILD HUNT

2,560 x 1,440, High Detail, AA on, HairWorks off




### THE WITCHER 3: WILD HUNT

3,840 x 2,160, High Detail, AA on, HairWorks off




Minimum Average

# Chillblast Fusion Lustre / £3,000 inc VAT

**SUPPLIER** www.chillblast.co.uk

This month's Labs test might have specified the use of GTX 108 GPUs, but there's another component inside the Chillblast Fusion Lustre that attracts just as much attention as Nvidia's Pascal GPU – Intel's Core i7-6900K processor. It's one of the beefiest consumer processors on the market.

For starters, it has eight Hyper-Threaded cores, so it can handle 16 simultaneous threads, and it has 20MB of L3 cache. Chillblast hasn't left the chip at its 3.2GHz stock speed either – it's added 1GHz to that figure.

Chillblast's machine is the only system on test to use the i7-6900K; two other rigs use the i7-6800K, while two more deploy the i7-6700K. Those two Skylake machines have higher overclocks than the Lustre, but will fall behind in heavily multi-threaded software due to fewer cores.

The Chillblast is the fastest PC in our application benchmarks

The rest of the Chillblast's components are suitably high-end. That GTX 1080 isn't overclocked, but it still has formidable gaming capabilities at stock speed. There's also 32GB of DDR4 memory, and the familiar storage combination of a 512GB Samsung SM951 M.2 SSD and a capacious 4TB hard disk.

Meanwhile, the Asus ROG Strix X99 Gaming (see p42) is a great motherboard with a feature set that includes on-board power and reset buttons, a POST code display and customisable RGB LED, which Chillblast has set to blue to match the lighting in the rest of the rig. The motherboard also includes dedicated audio circuitry and dual-band 802.11ac Wi-Fi.

Also, the lack of integrated graphics on LGA2011 systems means there's more room for ports, and Asus has obliged: the Chillblast's rear serves up four USB 3 connectors, four USB 2 ports, USB 3.1 Type-A and Type-C ports, and Wi-Fi aerial connectors. The front is similarly generous, with a Type-C connector included.

Meanwhile, the In Win 805 chassis uses a similar mix of glass and aluminium to Scan's In Win 909, but it measures just 476mm tall and 205mm wide. In terms of volume, it's virtually half the size of the Scan and Overclockers systems – good news if you don't have a lot of space for your PC.

There's no denying the Lustre's visual appeal either. Its tinted glass and matte black metal is illuminated by a strip of blue LEDs in the roof and more blue lights in the three 120mm case fans. The effect is alluring; blue light emerges through the side panel and the glass façade's honeycomb pattern. The light also bathes the CPU cooler, graphics card and RAM.

The design is smart, subtle and unfussy, and build quality is excellent. However, upgrade paths are limited – two of the four empty memory slots are blocked by the Corsair Hydro H80i cooler, and there's only one empty 3.5in hard disk bay. On the positive side, there are two vacant 2.5in bays around the back, and the ports, sockets, buttons and displays in the bottom half of the motherboard are all easy to reach. It's all powered by an 80 Plus Gold-rated Corsair PSU that's fully modular and has 850W of juice on tap – ample for this machine, and with enough headroom for a second GPU.

Finally, the PC is protected by Chillblast's five year warranty, which includes two years of collect and return parts coverage.

## /SPECIFICATIONS

**CPU** 3.2GHz Intel Core i7-6900K overclocked to 4.2GHz

**Motherboard** Asus ROG Strix X99 Gaming

**Memory** 32GB 2400MHz Corsair Vengeance LPX DDR4

**Graphics** Nvidia GeForce GTX 1080 8GB

**Storage** 512GB Samsung SM951 M.2 SSD; 4TB Seagate Barracuda hard disk

**Case** In Win 805

**Cooling** CPU: Corsair Hydro H80i v2 with 2 x 120mm fans; GPU: 1 x 70mm fan; front: 2 x 120mm fans; base: 1 x 120mm fan

**PSU** Corsair RM850x 850W

**Ports** Front: 1 x USB 3, 2 x USB 2, 1 x USB 3.1 Type-C, 2 x audio; rear: 4 x USB 3, 2 x USB 2, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 1 x PS/2, 1 x Gigabit Ethernet, 5 x audio

**Operating system** Windows 10 Home 64-bit

**Warranty** Two years parts and labour collect and return, followed by three years labour only return to base

## Performance

The Core i7-6900K is the most expensive and outlandish processor in this Labs test, so we expected it to perform well in benchmarks, and it delivered. The processor's eight cores battered our multithreaded Handbrake video encoding benchmark to a score of 507,042 – the best result in this test by more than 100,000 points. That's a huge score and a ludicrous margin of victory.

The huge core count saw the Chillblast outpace every other PC in our multi-tasking test too. The Chillblast only fell into second place in our Gimp image editing benchmark, because the Overclockers machine's Skylake CPU has a higher clock speed, and this mainly single-threaded test responds more to clock speed than multiple cores.

There's no denying that the Chillblast is the fastest PC when it comes to application benchmarks – its overall score

1 The tinted glass and matt black metal is illuminated by a strip of blue LEDs in the roof

2 With an 8-core CPU under the Corsair cooler, the Chillblast produced the fastest multi-threaded benchmarks on test

3 The NVMe SSD is quick, producing read and write rates of 1,967MB/sec and 1,483MB/sec respectively

of 201,105 is miles ahead of the nearest challenger. That's great if you're going to be doing a lot of multi-threaded rendering or video encoding work, but it will be overkill for most people, including gamers.

In our 2,560 x 1,440 game tests, the Chillblast romped through every test title, thanks to minimums that ranged between 53fps and 82fps. It also achieved playable frame rates in all our games at 4K, although it was technically this month's poorest performer in Crysis 3, with a 40fps average. The GTX 1080 is a barnstorming GPU, but it's clear that the 8-core CPU gives you no benefit here. The NVMe SSD is quick, though, with read and write rates of 1,967MB/sec and 1,483MB/sec respectively.

There are no thermal issues with the Chillblast either. Both the CPU and GPU delta Ts stayed at 60°C or below and the machine only made a low, quiet rumble without any modulation when the system was stress-tested. It's quieter than most gaming rigs.

## Conclusion

There's no denying the high price of this machine and, unlike the Scan and Overclockers PCs, you're paying for an 8-core CPU rather than water-cooling gear. The Chillblast has the most powerful processor in this test, and its application benchmark score is far ahead of the nearest rival – the eight cores mean it's especially good for heavily multi-threaded software.

There's no denying the power on offer from the GTX 1080 either, although in game benchmarks, the Lustre is no quicker than other single-card machines. The SSD is quick, the system is cool and quiet, and the case is subtle and relatively small.

The Chillblast Fusion Lustre is a fast and well-built machine if you're really going to use those eight CPU cores, and also want fast gaming performance, but if gaming is your priority, the Scan is quicker in games, while the cheaper Overclockers is just as quick in games and sports a gorgeous water-cooling system too.

| SPEED | DESIGN | OVERALL SCORE |
|---|---|---|
| 23/25 | 23/25 | 87% |
| HARDWARE | VALUE | |
| 22/25 | 19/25 | |

**VERDICT**

**Well designed, quiet and very fast in our application benchmarks, but the Chillblast is only worth its price if you regularly run heavily multi-threaded software.**

# CyberPower Arcus 34 Pro / **£2,399** inc VAT

**SUPPLIER** www.cyberpowersystem.co.uk

CyberPower's Arcus 34 Pro is a unique beast: a huge all-in-one PC with a curved 34in monitor that sits in front of a GTX 1080 and Core i7 processor. The screen is a PLS model, which is Samsung's version of IPS, so it should have great colour accuracy, reasonable contrast and decent viewing angles. The screen is also coated with a glossy layer rather than a matt finish.

Meanwhile, the Core i7-6700K processor runs its four Hyper-Threaded cores at their stock speed of 4GHz – one core can use Turbo Boost to hit 4.2GHz – and there's 16GB of 3000MHz DDR4 memory and a GTX 1080 running at its stock speed of 1607MHz. The tight confines don't just mean no overclocking either – they also mean a low-profile CPU cooler. CyberPower has used a Phanteks PH-TC90LS, which has a tiny heatsink topped with a 90mm fan.

The cramped interior also mean CyberPower has used a mini-ITX motherboard, but it still has plenty of features. The Gigabyte GA-Z170N-Gaming 5 has dual-band 802.11ac Wi-Fi, USB 3.1, an empty M.2 connector and a built-in audio amplifier. Its backplate also offer Killer Gigabit Ethernet and four USB 3 ports. Being a mini-ITX board, though, there aren't any PCI-E slots beyond the one already occupied, and both memory slots are already filled.

The rest of the space behind the screen is given over to daughterboards and other bits of hardware. There are two 5W speakers, an extension socket and cable for the GPU, a small board to handle the SSD, and another board that handles interfacing between the graphics card and the display. There are two power supplies too, but only one power cable is needed – an extension feeds electricity to the smaller unit that powers the screen.

It's all inside a chassis that mixes metal with plastic. However, while the metal legs are sturdy, the plastic backing is flimsy. It also looks plain, with a wide bezel and a simple CyberPower logo in one corner. It's not ugly, but the latest curved monitors with thin bezels look much more stylish.

CyberPower is going to build the Arcus with a huge range of alternative components, including any processor from a Pentium to a Core i7, and a choice of five different motherboards. There's huge variety in storage and memory configurations available too, and similarly broad choices are available for different GPUs.

Finally, the Arcus is protected by the usual CyberPower warranty: a three year labour deal with two years of parts coverage, with the first month offering collect and return cover.

### /SPECIFICATIONS

**CPU** 4GHz Intel Core i7-6700K

**Motherboard** Gigabyte GA-Z170N-Gaming 5

**Memory** 16GB Corsair Vengeance LPX 3000MHz DDR4

**Graphics** Nvidia GeForce GTX 1080

**Storage** 240GB Kingston SSDNow UV300 SSD; 1TB hard disk

**Case** Arcus AIO chassis

**Cooling** CPU: Phanteks PH-TC90LS with 1x 90mm fan; GPU: 1x 70mm fan; rear: 1x 50mm fan

**Monitor** 34in PLS, 3,440 x 1,440

**PSU** Ehance EMP-7145B2 450W

**Ports** Rear: 5 x USB 3, 1x USB 3.1 Type-A, 1x USB 3.1 Type-C, SDXC card reader, 1x PS/2, 1x Gigabit Ethernet, 1x optical S/PDIF, 7 x audio

**Operating system** Windows 10 Home 64-bit

**Warranty** Two years parts and labour return to base with one month of collect and return cover, followed by one year labour only return to base

## Performance

The screen sounds great on paper, but its benchmark results at factory settings were disappointing. The colour temperature of 11,023K is far beyond the 6,500K ideal, with an obvious, distracting blue pall. That's no surprise, as the panel has its 9,300K colour temperature mode selected by default. Colours weren't accurate, either: the average delta E of 12.94 is wayward, and the Gamma of 2.06 is short of the 2.2 benchmark. The final issue is brightness: the 116cd/m$^2$ backlight level is weak, which leaves the screen looking dim.

That latter issue is fixed by upping the backlight setting from its default of 30 to 75, which improved the brightness measurement to 204cd/m$^2$, while contrast remained at an impressive 1,854:1 – a figure that helped to deliver plenty of punch to lighter tones while serving darker areas with ample depth. Colours were still a problem, though, with the temperature and delta E figures largely unchanged.

The panel performed poorly when its Gaming mode was selected too, with the average delta E dropping to 15.35 and the panel's black level lightening to 0.2cd/m$^2$, resulting in worse colour reproduction and a lack of depth in dark areas. These issues were only rectified by calibration, which was achieved by fiddling with a multitude of settings: we pushed the green slider up a few notches, increasing the brightness and selected the panel's 6,500K colour option.

Benchmarks improved, with consistent contrast, a good average delta E of 1.18 and a revised colour temperature of 8,232K. That's still cool, but it doesn't leave the screen looking blue, and the calibrated panel is far more suited to playing games – graphics have more punch and accuracy, and contrast remains excellent. It's possible to get the panel to behave in games, but it takes a fair bit of work.

At least the screen uniformity is reasonable. The panel only loses up to 13 per cent of its brightness in its furthest corners, which is good for an ultra-wide panel – and the screen's curves are angled towards the user, which lowers the risk of dodgy patches appearing. It's fast-responding, too, with an input lag measurement of 11.8ms, lower than the ideal 20ms for gaming panels.

1 A full-sized GeForce GTX 1080 sits in the back of the chassis

2 A Gigabyte GA-Z170N Gaming 5 motherboard is used here, but there's a choice of five other mini-ITX boards too

3 The CPU is chilled by a Phanteks PH-TC90LS, which has a tiny heatsink topped with a 90mm fan

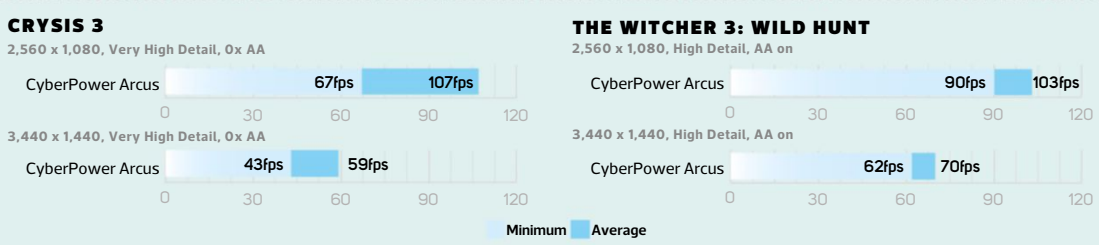
The screen is disappointing, but the Arcus improves in other benchmarks. Its lowest minimum frame rate at its native resolution of 3440 x 1,440 was 43fps in Crysis 3, and it stayed above 60fps in The Witcher 3. The stock-speed Core i7 is no slouch either, with solid scores in every benchmark. The speakers proved surprising too. They lack a little bass and volume, as there's no subwoofer, but they outputted nuanced and rich mid-range and high-end sound.

However, the other sound that emerges from the Arcus isn't as pleasant. The fans become louder and modulate their tones up and down even during light workloads, and the machine is louder still during games testing. It's on a par with a loud gaming desktop. The noise wasn't the only issue here. The tiny CPU cooler saw the i7-6700K hit a toasty delta T of 73°C, which meant that Turbo Boost didn't work – the chip stalled at 4GHz. Meanwhile, the GPU delta T topped out at 61°C, which isn't dangerous, but it's hot for a GTX 1080.

## Conclusion

CyberPower's all-in-one machine is a great idea in principle, saving space to make room for a massive screen. However, it needs a great-quality screen to make the design work, and the one in the Arcus suffers from issues with colour accuracy and temperature. The exterior also has a dull design and uninspiring build quality.

On the plus side, while the form factor limits the spec, with a mini-ITX motherboard and stock-speed components, there's no doubting the gaming power on offer – you'll be able to play games at the screen's native resolution with no trouble – it's much more powerful than you'd expect for an all-in-one PC, and the use of standard components also means it's upgradable. However, at £2,399 inc VAT, you could buy an overclocked desktop with the same components and a much better screen. It's a great idea, but the reality doesn't quite meet expectations.




SPEED 19/25

DESIGN 19/25

HARDWARE 18/25

VALUE 20/25

OVERALL SCORE 76%

**VERDICT**

A great premise, but a disappointing screen means this PC isn't quite the sum of its parts.

# Oblivion Systems Barbarian / £1,722 inc VAT

**SUPPLIER** www.oblivionsystems.co.uk

The Barbarian from Hitchin-based Oblivion is the most compact PC in this test. Its Phanteks Eclipse P400 case has a modest height of 65mm, and it doesn't have the dramatic angled sections of the PC Specialist's NZXT Phantom. Despite its low price, there's a lot to like about the Eclipse P400 beyond its modest dimensions too. The subtly angled front panel looks smart and it's illuminated from below with a blue LED underneath the plastic, while the power button sits in the middle of the roof, with a choice of lighting colours surrounding it.

The case's white exterior contrasts well with the black insides too. The PSU shroud and motherboard tray are black, and Oblivion has augmented the dark design with black memory and a black Oblivion-branded 240mm closed-loop liquid-cooling system for the CPU.

Splashes of colour are carefully coordinated. The Gigabyte GA-Z170X-Gaming 7 motherboard's black PCB is accented with red and white heatsinks and LEDs, and the main power cables are also braided (by third-party firm To The Wire) with those colours. They look distinctive and tidy, contributing to a good-looking system. Then there's the NZXT Hue+ RGB lighting system, which sits in the top of the machine, illuminating the internals.

The relative simplicity of the build also makes it easy to work with this machine. Its two memory slots and the numerous connectors in the bottom half of the board can all be accessed without any trouble, and there are two free SSD mounts around the back.

Any complaints with the chassis and basic setup are minor. The shroud that covers the PSU and hides cables is a little flimsy and there's no extra room for 3.5in drives – one bay is already occupied by a hard disk, and the other houses the Hue+ control box. There are no 5.25in bays either, but that may not be an issue, depending on how you buy your software and media.

The Barbarian's star component is the Gigabyte GTX 1080 card. It's a Founders Edition card with Nvidia's cooler, as with most of the machines on test and, like most of the machines on test, the card runs at stock speeds –only the Scan has an overclocked GTX 1080 card.

Nvidia's new card is bolstered by a Core i7-6700K, which Oblivion has overclocked to 4.6GHz – just only 100MHz behind the Overclockers system, which uses the same chip. The Core i7-6700K is an interesting choice of chip. It's fast, but half of this month's machines contain Broadwell-E silicon. Those processors don't reach the clock speeds that the i7-6700K can hit, but they all have more cores for multi-threaded software.

Meanwhile, the good-looking motherboard is packed with features. It's the only machine on test with a second M.2 connector, and it has the full set of on-board buttons alongside a POST code display. The rear I/O panel, which includes Type A and C USB 3.1 ports, is also spiced up by an LED that bathes the USB connectors and audio jacks in a dramatic red glow.

The Barbarian is this month's cheapest machine, which means the budget is cut in other areas. It gets the important parts right though. There's 16GB of 3200MHz DDR4, and while pricier systems have twice as much memory, that's still enough for most people and it's more than enough for games. It's great to see an M.2 NVMe Samsung 950 Pro SSD too, although it only offers 256GB of storage space. Meanwhile, the SuperFlower PSU has an 80Plus Gold rating, which matches rival machines. Its rated 750W power output is less than most other machines in this Labs test, but it's more than enough for the spec in the Barbarian, and has enough headroom to add a second graphics card in SLI configuration too.

The Oblivion-branded CPU cooler doesn't have any fancy lighting or tubing either, although it does at least have a large 240mm radiator with a couple of 120mm fans on it. It only cools the CPU, however, and there isn't any high-end cooling gear elsewhere, with just single 120mm intake and exhaust fans keeping the chassis cool.

Finally, the Barbarian includes a two-year return to base warranty that covers parts and labour, which is fine. It might not have the extra years of labour cover and collect and return features of some of the other manufacturers' warranties in this Labs test, but it's the two years of parts coverage that are the important factor.

### /SPECIFICATIONS

**CPU** 4GHz Intel Core i7-6700K overclocked to 4.6GHz

**Motherboard** Gigabyte GA-Z170X-Gaming 7

**Memory** 16GB Team Group Dark Pro 3200MHz

**Graphics** Gigabyte GeForce GTX 1080 8GB Founders Edition

**Storage** 256GB Samsung 950 Pro M.2 SSD; 2TB Western Digital hard disk

**Case** Phanteks Eclipse P400

**Cooling** CPU: Oblivion 240mm all-in-one liquid cooler with 2 x 120mm fans; GPU: 1 x 70mm fan; front: 3 x 120mm fans; rear: 1 x 120mm fan

**PSU** SuperFlower Leadex 750W

**Ports** Front: 2 x USB 2, 2 x audio; rear: 5 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 1 x PS/2, 2 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

**Operating system** Windows 10 Home 64-bit

**Warranty** Two years parts and labour, return to base

1 **The red and white PSU cables, braided by To The Wire, give the interior a smart appearance**

2 **An NZXT Hue+ RGB lighting system sits in the top, illuminating the internals**

3 **The Core i7-6700K CPU has been overclocked to 4.6GHz**

## Performance

There's no doubt about the GTX 1080's ability to handle games. The Barbarian turned in a minimum of at least 83fps in every title at 1080p, and then ran through our 2,560 x 1,440 tests at 53fps or higher. That's only a little way short of the magic 60fps figure. The Oblivion handled our 4K tests with aplomb, too, although it was sometimes a little behind the other single-GPU machines on test. It maintained playable frame rates above 25fps in all our test games at 4K, though, which is a great result at this price.

The Oblivion's application benchmark results fell behind the other machines on test, but that isn't a shock – the Overclockers machine has a higher clock speed, and the other systems have Broadwell-E chips with more cores. That said, there's no shame in this Core i7 chip's scores – after all, there's still ample power here to get work done, and the performance differences are tiny.

The SSD performed as expected too, with sequential reads and writes of 2,118MB/sec and 1,256MB/sec. That's far quicker than a SATA drive, and on a par with other M.2-based drives in this test.

So far, so good, but where the Barbarian falls down is when it comes to thermals and noise. The GPU and CPU delta Ts of 59°C and 65°C aren't dangerously hot, but few systems in this Labs test are warmer. The P400 is a great chassis, but it gets hot with an overclocked system inside it. The Barbarian isn't particularly quiet either. When idle, its fans produce a noticeable rumble, and it's louder when running games. It's on a par with the huge Overclockers system in terms of noise.

## Conclusion

The Oblivion Systems Barbarian is the cheapest machine in this Labs test, but it still offers a good selection of core components. The GeForce GTX 1080 is fast and the overclocked Core i7 chip provides enough power to handle most workloads – only people using heavily multi-threaded software will benefit from more cores. The motherboard is great for the money too, with good looks and several fancy features.

However, you make some sacrifices to get a lower price. There's only 256GB of solid state storage, for example, and the Barbarian is comparatively hot and noisy too. If you have a tight budget and want a fast gaming system, the Oblivion Barbarian delivers all the goods, but it's also a little rough around the edges.

| SPEED | DESIGN | OVERALL SCORE |
|---|---|---|
| 21/25 | 20/25 | 83% |
| HARDWARE | VALUE | |
| 19/25 | 23/25 | |

**VERDICT**

**Solid core performance for a great price, although the Barbarian is comparatively hot and noisy.**

# Overclockers Techlabs Chameleon / £2,500 inc VAT

**SUPPLIER** www.overclockers.co.uk

The Chameleon is the largest PC in this Labs test by some distance, with its Phanteks Enthoo Primo standing 650mm tall, with a width of 250mm. It weighs almost 20kg too. Its front is a looming tower of matt black plastic, with a ring of meshed air intake and a door across five 5.25in drive bays, while the roof has a swathe of mesh. The side panel has a huge window and a smaller see-through section to show off the Phanteks logo, and those windows show off the white interior – a stark and attractive contrast to the black outside.

The entire rig exhibits exemplary build quality. The top, bottom and rear edges are lined with NZXT Hue+ lighting strips, set to produce white light. Meanwhile, the hardline tubing is filled with white Mayhems coolant, which looks fantastic bubbling in the EK X3 250 reservoir. The whole setup looks even better when cast against the white camouflage finish of the Asus motherboard.

There's some contrast in the colour scheme too, thanks to the rest of the cooling hardware. The EK waterblocks are both black, and the two EK-CoolStream XE 240mm radiators are black too.

The two-tone design emerges from Overclockers' new Chameleon range, which aims to give customers more colour choices. Buyers can choose a basic colour scheme determined by the case and motherboard, and Overclockers echoes that look with its cooling and lighting. At the time of writing, there are orange, green and red schemes available.

The huge size of this machine means there's also loads of space inside it, despite the huge radiators. There's plenty of room to get to the connectors and slots at the bottom of the motherboard, and there's room to manoeuvre into the two empty memory slots as well.

There's clear air around the back, too. Four empty, tool-free hard disk caddies are hidden behind a shroud, and there are numerous spare 5.25in bays. There's room for three 2.5in drives, and the EK-XTOP Revo D5 pump sits behind the PSU cover. Meanwhile, the NZXT Hue+ controller sits in a hard disk bay. The Chameleon offers more upgrade paths than any other PC in this test and, crucially, it's easy to access every potential improvement.

There are undeniable visual comparisons to be drawn between the Overclockers machine and Scan's Labs entrant. Both are huge, and deploy stunning hardline water-cooling loops with black and white colour schemes. Get to the spec sheets, though, and the comparisons vanish – the Scan machine has two overclocked GTX 1080s and a Broadwell-E CPU, while the Overclockers rig has one stock speed GTX 1080 and a Skylake Core i7-6700K processor.

On paper, the Overclockers machine looks disadvantaged compared with the Scan, PC Specialist and Chillblast systems with their Broadwell-E silicon, but it still makes a lot of sense for gaming, where higher clock speeds on a few cores are better than many cores with lower clock speeds. Thanks to all the water-cooling gear, Overclockers has given the Core i7-6700K massive overclock to 4.7GHz.

There's also 16GB of 3000MHz RAM and again, while other PCs offer 32GB, the impact in games and software most people use will be negligible. However, the 256GB Samsung 950 Pro NVMe SSD is a bit small for this price. There's at least a 2TB hard drive to cover further storage needs, but a 512GB SSD would be welcome here.

The power supply is worth mentioning too: it's an 800W BeQuiet! unit with headroom for a second GPU and a fully modular design, plus it has 80Plus Gold certification. There's also plenty to like about the Asus Sabertooth Z170 S motherboard, in addition to its white camouflage colour scheme. It has plenty of free ports and slots, active VRM cooling for overclocking, a smart row of five white LEDs to highlight the boot process and both Type-A and Type-C USB 3.1 ports. There are a handful of notable features missing though. There's no Wi-Fi, for example, or on-board power and reset buttons.

## Performance

The Core i7-6700K doesn't have as many cores as Broadwell-E chips, but its higher clock speed gave it a leg up on single-GPU rivals in games benchmarks. It blitzed every game at 2,560 x 1,440, where its lowest minimum of 57fps is still a great result. Where it really excelled, though, was in our 4K tests - only the two-GPU systems were faster here. In Crysis, 3 its 29fps minimum equalled the two other

### /SPECIFICATIONS

**CPU** 4GHz Intel Core i7-6700K overclocked to 4.7GHz

**Motherboard** Asus Sabertooth Z170 S

**Memory** 16GB TeamGroup Dark Pro 3000MHz DDR4

**Graphics** Asus GeForce GTX 1080 8GB

**Storage** 256GB Samsung 950 Pro M.2 SSD; 2TB Seagate Barracuda hard disk

**Case** Phanteks Enthoo Primo

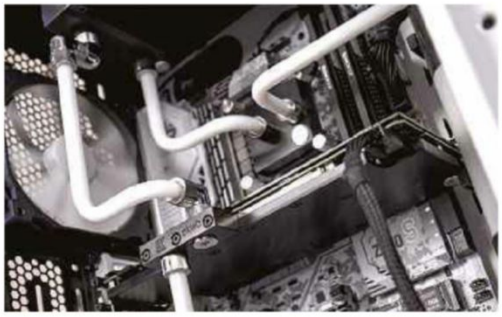
**Cooling** CPU: EK-Supremacy EVO waterblock, EK-CoolStream XE 240/360 radiators, EK-RES X3 250 reservoir, EK-XTOP Revo D5 pump; 5 x 120mm fans; GPU: EK-FC1080 GTX waterblock; front: 2 x 140mm fans; rear: 1 x 140mm fan

**PSU** Be Quiet! Straight Power 10 800W

**Ports** Front: 2 x USB 3, 2 x USB 2, 2 x audio; rear: 2 x USB 3, 4 x USB 2, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 1 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

**Operating system** Windows 10 Home 64-bit

**Warranty** Two years parts and labour collect and return, followed by one year labour only return to base



1 **The white Mayhems coolant looks great bubbling in the EK X3 250**

2 **It's great to see a PCI-E 3 NVMe SSD, but the 256GB Samsung 950 Pro doesn't offer much capacity**

3 **The top, bottom and rear edges are lined with NZXT Hue+ lighting strips**

traditional desktops with single GTX 1080 GPUs, nearly hitting the 30fps mark, and in Fallout 4, its 27fps minimum was slightly ahead of the competition too.

The Chameleon stretched its lead in The Witcher 3 as well, where its 46fps minimum was 3fps ahead of the nearest single-GPU competitor.

However, the quad-core processor means the Chameleon returned mixed results in application tests. Not surprisingly, the 4.7GHz CPU led the way in our image editing benchmark, where single-threaded performance is key, but it fell behind the Broadwell-E machines in our multi-threaded H.264 Handbrake video encoding benchmark.

That said, the Chameleon is primarily a gaming machine, and it has power where it counts. You'll only benefit from extra CPU cores if you use a lot of heavily multi-threaded software. Meanwhile, the familiar Samsung SSD returned read and write speeds of 1,834MB/sec and 1,381MB/sec, which are superb.

The Techlabs Chameleon also produced interesting thermal results. The water-cooling system has enabled Overclockers to push the CPU all the way up to 4.7GHz, but its CPU delta T of 62°C is still pretty high. That temperature is still well within thermal limits, though, so it's no cause for concern. On the plus side, the GPU delta T of 35°C was a fantastic result – it's a shame Overclockers didn't push the GPU clock speeds any further, but there's clearly room for you to do so if you're happy to risk it.

Unfortunately, this PC's cooling system is never particularly quiet. It emits an obvious low rumble when idle, and the noise only increases during games – it's one of the loudest machines in this Labs test.

## Conclusion

Overclockers' Techlabs Chameleon makes a big statement with its huge case and attractive water-cooling system, but there's more to this PC than its looks. The ambitious CPU overclock helps the GTX 1080 to squeeze beyond its rivals in games tests, and is arguably more appropriate for a gaming machine than a Broadwell-E chip anyway, although the latter definitely has the upper hand in multi-threaded speed.

The Chameleon is a huge, eye-catching machine that offers lots of power and plenty of room to grow, but it's also not particularly quiet and it's a shame the GPU hasn't been overclocked when there's so much cooling potential. When low-noise operation and/or overclocking headroom are the main advantages of water cooling, aside from aesthetics, you can't help thinking Overclockers has missed a trick here.

| SPEED | DESIGN | OVERALL SCORE |
|---|---|---|
| 22/25 | 23/25 | 87% |
| HARDWARE | VALUE | |
| 21/25 | 21/25 | |

**VERDICT**

**A monster PC with solid components, great looks, well-balanced performance and plenty of room to grow, although it makes a fair bit of noise.**

# PC Specialist Vanquish Gamer Extreme III / £2,430 inc VAT

**SUPPLIER** www.ebuyer.co.uk

With words such as 'Vanquish' and 'Extreme' in its moniker, PC Specialist's rig means business. It's one of only two machines in this Labs test to deploy two GTX 1080 cards, which immediately brings huge numbers to mind, offering 16GB of GDDR5X memory and more than 5,000 stream processors to power any game at 4K and beyond.

There's also a 3.4GHz Intel Core i7-6800K processor with six Hyper-Threaded cores and 15MB of L3 cache. This machine offers huge power in both the CPU and GPU departments. The pair of graphics cards will scythe through any current game, and the multi-threaded CPU will handle demanding applications and high-end multi-tasking.

Those components plug into an Asus Strix X99 motherboard, which features RGD LEDs all over the heatsinks and PCI-E slots, while sporting on-board power and reset buttons, and dual-band 802.11ac Wi-Fi. There's a lot to like elsewhere, too, including an M.2 socket, SupremeFX audio and plenty of empty ports and connectors.

It's an impressive array of hardware for a PC that costs £2,430 inc VAT, but the Vanquish isn't as accomplished in some other departments. Its 16GB of memory is fine, but its 2133MHz speed is the bare minimum for DDR4. PC Specialist has eschewed a rapid PCI-E M.2 SSD for a conventional SATA model, too. The overclocks lack ambition too: the GPUs run at stock speeds, while the CPU rattles along at a modest 4.2GHz.

All the hardware is packed inside an NZXT Phantom 410 chassis, with an emphasis on the word 'packed'.

The Phantom only measures 516mm tall and 215mm wide, which leaves the interior pretty cramped – the two graphics cards are huge, all of the removable hard disk cages have been left in place, and the hefty Corsair RM850x power supply occupies a big space at the bottom of the case. That's a good PSU, by the way, offering more than enough oomph for the two GPUs and Broadwell-E processor, and it has an 80Plus Gold rating.

The PSU's modular cables have been bundled together and kept out of the way, but nothing has been done to jazz them up, unlike Oblivion's custom braiding, for example. There isn't any extra lighting, either, you just get what's already on the motherboard.

On the plus side, the upgrade room is reasonable. Despite the cramped conditions, there are loads of storage bays and memory slots free. The various sparer PCI-E slots are either blocked or tricky to reach though. There's nothing special about the cooling either – there's a decent Cooler Master Hyper 212 Evo air cooler, but no liquid cooling, and there are plain single fans in the front, exhaust and roof, but that's it.

The case itself is a decent mid-tower, although its plastic roof and front sections don't feel that solid for a machine of this price. The side panels aren't as strong as the thicker metal panels on other enclosures, either.

Basically, there isn't much in the way of extras – your budget is going on a very fast processor and two very fast graphics cards – but that's not necessarily bad; it's just a question of your priorities. The Scan is better balanced and better looking, but it's also massively more expensive.

Finally, the PC Specialist is protected by one year of parts and labour coverage, which includes a month of collect and return cover, and the warranty then reverts to a two year labour only return to base deal. That's not bad, but it's bettered by other manufacturer's offerings. Scan's machine, by way of contrast, has a year of on-site service, and the Chillblast has two years of collect and return coverage for both parts and labour.

## Performance

The addition of a second GTX 1080 helps the PC Specialist to deliver incredible 4K gaming performance. Its lowest frame rate at 3,840 x 2,160 came in Fallout 4, but even then, its 48fps minimum is superb. It was quicker in Crysis 3, and faster still in The Witcher 3. Suffice to say that this machine won't struggle with high-end games.

Don't worry about playing games at lesser resolutions either: the PC Specialist never dropped below 100fps in any of our games at either 2,560 x 1,440 or 1080p. Of course, the Scan system has two overclocked GTX 1080s, which

### /SPECIFICATIONS

**CPU** 3.4GHz Intel Core i7-6800K overclocked to 4.2GHz

**Motherboard** Asus Strix X99 Gaming

**Memory** 16GB Kingston HyperX Fury 2133MHz DDR4

**Graphics** 2 x Nvidia GeForce GTX 1080 8GB

**Storage** 480GB Kingston V300 SSD; 2TB Toshiba hard disk

**Case** NZXT Phantom 410

**Cooling** CPU: Cooler Master Hyper 212 Evo with 1 x 120mm fan; GPU: 2 x 70mm fans; front: 1 x 120mm fan; rear: 1 x 120mm fan; roof: 1 x 140mm fan

**PSU** Corsair CS750 750W

**Ports** Front: 2 x USB 3, 2 x USB 2, 2 x audio; rear: 4 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 4 x USB 2, 1 x PS/2, 5 x audio

**Operating system** Windows 10 Home 64-bit

**Warranty** One year parts and labour collect and return, followed by two years labour only return to base

1 With two GTX 1080 GPUs, there's no stopping this machine in games

2 A simple Cooler Master Hyper 212 Evo cools the overclocked CPU

3 All of the removable hard drive cages have been left in place

makes it a little quicker than the PC Specialist, with minimums sitting a couple of frames per second ahead in Fallout 4 and The Witcher 3, and with consistently better averages. However, the differences are small – the PC Specialist is clearly a formidable gaming machine.

The PC Specialist almost keeps up with the Scan machine in application benchmarks too. Both systems run their Core i7-6800K CPUs at the same frequency, but the Scan has faster storage and memory. Even so, with six cores under its belt, the PC Specialist was very quick in our heavily multi-threaded Handbrake video encoding test. Not surprisingly, though, it lagged behind the Skylake-based Overclockers machine in our Gimp image editing test, which relies on single-threaded performance.

The PC Specialist's reduced budget had an impact on other benchmarks though. The Kingston SATA SSD delivered sequential read and write speeds of 519MB/sec and 496MB/sec. They're decent results for a SATA drive, but several times slower than the Samsung 950 Pro inside the Scan and Chillblast machines.

Not surprisingly, the air-cooled Vanquish isn't as cool as systems with liquid-cooled components, although it copes surprisingly well with these powerful components' thermals. The GPU delta T of 34°C is excellent, and while the CPU delta T of 59°C is a little warm, it's well within thermal limits.

We're pleased to report that noise was never an issue either – even during stress tests, the Vanquish remained extremely quiet, so there's no need to deploy either of the two higher fan speed settings.

## Conclusion

There's a lot to like about this PC Specialist rig. Its two GTX 1080 cards will handle any game at 4K, offering a huge boost over single-GPU machines, and their performance is barely behind the Scan's overclocked GPUs. It's fast in applications, with Broadwell-E silicon that excels in heavily multi-threaded software, and the motherboard is good.

That said, the Vanquish could be better balanced. It has slower storage and memory than some rivals and the case is cramped, without the room or style of other enclosures. However, it can deliver fearsome power and it makes a good alternative to the expensive Scan if gaming performance is your top priority. It's just a shame the CPU and GPUs aren't better complemented by some of the other components.

| SPEED | DESIGN | OVERALL SCORE |
|---|---|---|
| 23/25 | 20/25 | 85% |
| HARDWARE | VALUE | |
| 20/25 | 22/25 | |

**VERDICT**

**Huge speed from two GPUs and Broadwell-E silicon, and it's quiet too, although the component choices could be better balanced elsewhere.**

# Scan 3XS X99 Carbon Fluid GL SLI / £4,100 inc VAT

**SUPPLIER** www.scan.co.uk

This month's most expensive machine comes from Scan, and it's no surprise that the 3XS X99 Carbon Fluid GL SLI tips the scales at more than £4,000 when you see the spec. For starters, it's one of only two machines in this group to include a pair of GeForce GTX 1080 cards. That enviable graphics hardware is paired with a Broadwell-E processor, a large M.2 NVMe Samsung SSD, 32GB of memory and an expensive motherboard.

Scan has also slotted its components into one of the biggest cases seen in this test – the great-looking In Win 909 – and it keeps them chilled with a slick, extensive water-cooling loop. The hardline acrylic tubing is filled with white coolant, circulated by an EK pump and reservoir.

The 360mm radiator is hidden in the gap between the motherboard and the case's rear, and the entire machine looks stunning – the white tubes look fantastic, and the matt black fittings contrast well. To our tastes, the Scan's black and white colour scheme even looks a tad better than the metallic fittings in the Overclockers machine (see p60).

There's a lot to like about the In Win 909 too. The exterior is made from a single 4mm sheet of anodised aluminium, and its side panels are hewn from 5mm slabs of tinted, tempered glass. It looks superb, and it's built around a rock-solid metal skeleton.

A separate compartment at the top houses four discrete hard disk caddies, and ample cable routing options have enabled Scan to keep the cables tidy. Two 140mm fans at the bottom draw air inside, while three fans on the reservoir pull air backwards. All the fans have white LEDs, and Scan has fitted a strip light at the bottom of the case. A button on the front I/O panel changes the pattern of those lights, and Scan has also fitted a custom 3XS Systems metal logo to the front of the machine.

Meanwhile, the PSU sits in a separate, hidden compartment, along with a USB stick of diagnostic tools, while the case's rear holds well-routed cables and two empty 2.5in bays.

Scan has turbo-charged the components too, taking advantage of the cooling system by raising the GPUs' 1607MHz base clocks to 1732MHz, while adding 250MHz to the graphics card memory clocks.

The Carbon Fluid pairs its two GPUs with a Core i7-6800K CPU. It's the entry-level Intel Broadwell-E chip, and its six cores make more sense for a gaming rig than an 8-core or 10-core monster. The only downer is that it only has 28 PCI-E 3 lanes to cover the bandwidth of two GPUs and an M.2 SSD, meaning the lane allocation to the motherboard's 16x PCI-E graphics slots has to be compromised. Scan has tweaked the i7-6800K, too, upping its 3.4GHz core to 4.2GHz – a modest but welcome boost.

### /SPECIFICATIONS

**CPU** 3.4GHz Intel Core i7-6800K overclocked to 4.2GHz

**Motherboard** Asus X99-A II

**Memory** 32GB Corsair Vengeance LPX 2666MHz DDR4

**Graphics** 2 x EVGA GeForce GTX 1080 8GB

**Storage** 512GB Samsung 950 Pro M.2 SSD; 2TB Western Digital Blue hard disk

**Case** In Win 909

**Cooling** CPU: EK Supremacy waterblock, EK XRES 140 Revo D5 pump and reservoir, EK CoolStream PE 360 radiator and 2 x 120mm fans; GPU: 2 x EK FC-1080 waterblocks; bottom: 2 x 140mm fans

**PSU** Corsair RM750x 750W

**Ports** Front: 3 x USB 3, 1 x USB 3.1 Type-C, 2 x audio; rear: 4 x USB 3, 4 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 1 x Gigabit Ethernet, 1 x PS/2, 1 x optical S/PDIF, 5 x audio

**Operating system** Windows 10 Home 64-bit

**Warranty** Three years parts and labour – one year on-site, followed by two years return to base

The rest of the specification is similarly muscular. There's 32GB of DDR4 memory clocked to 2666MHz and a 512GB Samsung 950 Pro boot drive. The Asus X99-A II motherboard (see Issue 155, p24) also ticks several boxes. Its slick black and white heatsinks are augmented by customisable RGB LEDs, and it's littered with ample expansion room, plus on-board power and reset buttons next to a POST code display.

The sheer wealth of hardware inside the Scan PC means some motherboard features are hard to access though. The spare PCI-E slots and SATA connectors are hidden behind water-cooling hardware, and the same is true of every connector at the bottom of the board. It's only a peripheral concern, as many people won't be opening this system to install more hardware anyway, but it's worth bearing in mind.

The same can be said about the In Win case's tricky port positioning and I/O access. The three USB 3 connectors and single USB 3.1 Type-C port sit at the bottom of the chassis along with the power button – potentially awkward to access, depending on how the PC is positioned. Scan has also used the hefty metallic I/O cover to hold the 360mm radiator, so we had to awkwardly thread cables our peripheral and monitor cables through the hole, and take off the side panel, to reach the GPU outputs and rear I/O. Of course, most people won't need to access these ports on a regular basis, but it's a faff when you do need to get to them.

## Performance

There's no doubt about it – the Scan's two overclocked GPUs deliver this month's best gaming performance. In our 4K tests, the pair of GTX 1080s never even dropped below 50fps, and the minimum of 59fps in The Witcher 3 is incredible – you could comfortably turn on features such

1 **The pair of overclocked GTX 1080 cards makes the Scan the fastest PC on test in games**

2 **The custom-made, hardline water-cooling loop is filled with white coolant**

3 **The 6-core CPU is overclocked to 4.2GHz**

as HairWorks and the game would still be smooth at 4K.

This performance is slightly ahead of the PC Specialist, which had two stock-speed GTX 1080s. It's also further ahead of the rest of this month's machines, which had single GTX 1080s and sometimes struggled to get beyond 30fps minimums in 4K benchmarks.

The overclocked Core i7-6800K held its own in application benchmarks too, trading blows with some of this month's other tweaked chips. It's no surprise that the Chillblast has the lead in our heavily multi-threaded Handbrake video encoding benchmark, as it has two extra cores, but the Scan's overclocked Core i7-6800K held its own in the rest of the tests, occasionally swapping places with the Skylake-based Overclockers machine, thanks to the latter's higher clock speed. The Carbon Fluid rattled through the application benchmarks to score 162,330, which is the second fastest score on test.

The benchmarks are bolstered by good performance elsewhere too. The Samsung SSD's sequential read and write speeds of 1,993MB/sec and 1,386MB/sec are excellent – far better than the SATA drive in the PC Specialist, for example. The 6800K may not give you the full allocation of lanes for the graphics and SSD setup, but it clearly doesn't have much of an impact on real-world performance.

The Scan's cooling system also proved exceptional in tests. The CPU and GPU delta Ts of 41°C and 25°C are far cooler than the results you'd expect from air cooling. Scan's machine even keeps down the noise; despite it being one of this month's beefiest machines, it's also one of the quietest. It's barely audible during low-intensity tasks, and it's only a little louder when running games.

## Conclusion

Scan's 3XS X99 Carbon Fluid GL SLI is the most expensive machine in this Labs test, but it's easy to see where the money has been spent. The high-end components are paired with an impressive glass chassis and an extensive, well-built water-cooling system. The Scan backs up its spec sheet and good looks with excellent benchmark scores too – the Scan is the fastest PC on test in games, and it's consistently close to the top of the graphs in the application results. It's cool and quiet too.

PC Specialist's Vanquish Gamer Extreme III can deliver similar performance for less cash, of course, but it isn't as accomplished and well balanced as the Scan. The Scan 3XS X99 Carbon Fluid GL SLI is certainly pricey, sure, but it has no problem justifying the outlay.

| SPEED | DESIGN | OVERALL SCORE |
|---|---|---|
| 24/25 | 24/25 | 92% |
| HARDWARE | VALUE | |
| 24/25 | 20/25 | |

**VERDICT**

**Table-topping games performance, solid components and top-notch design make the Scan an excellent premium PC if you can afford it.**

# Elite

Our choice of the best hardware available

## Build a home theatre PC

**The parts you'll need to build an affordable, home theatre PC that's ideal for putting in the lounge and playing back all manner of video formats. This machine will handle general computing and media tasks with no trouble, and its dual-core Skylake CPU can even handle 4K video playback. Meanwhile, its super-quiet Noctua CPU cooler prevents it from making a racket.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | Lian Li PC-Q09FNB with 300W FSP SFX PSU | www.overclockers.co.uk | Issue 149, p92 | £110 |
| | Intel Core i3-6100T | www.overclockers.co.uk | Issue 149, p92 | £102 |
| | Asus H110i-Plus D3 | www.scan.co.uk | Issue 149, p92 | £60 |
| | 8GB Corsair 2133MHz Vengeance LP DDR3 (CML8GX3M2A2133C11B) | www.scan.co.uk | Issue 149, p92 | £41 |
| | Noctua L9i | www.scan.co.uk | Issue 149, p93 | £32 |
| | Samsung SN-208FB | www.overclockers.co.uk | Issue 149, p93 | £15 |
| | Seagate Barracuda 2TB ST2000DM001 | www.scan.co.uk | Issue 104, p75 | £55 |
| | Samsung 850 Evo 250GB | www.scan.co.uk | Issue 141, p51 | £75 |
| | Logitech K400 Plus | www.scan.co.uk | Issue 149, p93 | £30 |
| | Microsoft Windows 10 Home Retail USB drive | www.scan.co.uk | Issue 146, p17 | £85 |
| | | | TOTAL | £605 |

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# Build a budget gaming PC

**The parts you'll need to build a budget machine capable of playing the latest games at maximum settings on a 1080p monitor, and even some games at 2,560 x 1,440. The machine has a discrete graphics card, a Skylake dual-core CPU and DDR4 memory. The ASRock Extreme4 motherboard is also capable of base clock overclocking via a BIOS update.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | NZXT S340 | www.overclockers.co.uk | Issue 137, p54 | £53 |
| | ASRock Z170 Extreme4 | www.scan.co.uk | Issue 151, p84 | £109 |
| | Intel Core i3-6100 | www.scan.co.uk | Issue 151, p18 | £100 |
| | 8GB (2 x 4GB) Corsair Vengeance LPX 2400MHz (CMK8GX4M2A2400C16) | www.scan.co.uk | Issue 151, p83 | £35 |
| | Asus Radeon R9 380 Strix 2GB | www.ebuyer.com | Issue 150, p48 | £154 |
| | Samsung 850 Evo 250GB | www.scan.co.uk | Issue 141, p51 | £75 |
| | SilverStone Argon AR01 | www.scan.co.uk | Issue 132, p57 | £26 |
| | EVGA SuperNova GS 550W | www.cclonline.com | Issue 146, p50 | £73 |
| | Seagate Barracuda 2TB ST2000DM001 | www.scan.co.uk | Issue 104, p75 | £55 |
| | Microsoft Windows 10 Home Retail USB drive | www.scan.co.uk | Issue 146, p17 | £85 |
| | | | **TOTAL** | **£765** |

# Build a mid-range PC

## Work PC

**The parts you'll need to build a solid quad-core PC with plenty of upgrade potential. This kit list gives you an all-in-one liquid cooler and a K-series Core i5 Skylake CPU, meaning you can overclock it and get some serious processing power. We've managed to get the Core i5-6600K Skylake CPU up to 4.6GHz, so it has some great performance potential. Also included is a solid EVGA PSU, afast M.2 SSD and 8GB of high-speed DDR4 memory. The core configuration assumes you won't be doing any serious gaming, however, and it relies on Intel's integrated graphics.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | NZXT H440 2015 Edition | www.overclockers.co.uk | Issue 154, p50 | £95 |
| | Asus Maximus VIII Ranger | www.scan.co.uk | Issue 147, p44 | £153 |
| | Intel Core i5-6600K | www.scan.co.uk | Issue 145, p17 | £200 |
| | 8GB Corsair Vengeance LPX 2666MHz DDR4 (CMK8GX4M2A2666C16) | www.scan.co.uk | Issue 145, p24 | £38 |
| | NZXT Kraken X41 | www.overclockers.co.uk | Issue 138, p57 | £80 |
| | EVGA SuperNova GS 550W | www.cclonline.com | Issue 146, p50 | £73 |
| | Seagate Barracuda 2TB ST2000DM001 | www.scan.co.uk | Issue 104, p75 | £55 |
| | Samsung SSD 950 Pro 256GB | www.ebuyer.com | Issue 149, p48 | £139 |
| | Microsoft Windows 10 Home Retail USB drive | www.scan.co.uk | Issue 146, p17 | £85 |
| | | | **TOTAL** | **£918** |

## Gaming PC

**The graphics card you'll need to play current games at their maximum settings at 1080p and 2,560 x 1,440.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | **1,920 x 1,080** Asus Radeon R9 380 Strix 2GB | www.ebuyer.com | Issue 150, p48 | £154 |
| | **2,560 x 1,440** AMD RX480 8GB **UPDATED** | www.overclockers.co.uk | Issue 156, p19 | £219 |

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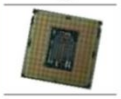
PERFECT YOUR BUILD FROM COOLING TO COLOUR

# Build a performance PC

## Work PC

**The parts you'll need to build a high-quality, fast PC that's ideal for multi-threaded workloads. This kit list features a high-quality, well-built case, a feature-rich motherboard and an Intel Skylake Core i7-6700K CPU. This processor's support for Hyper-Threading splits the resources of the CPU's four physical cores into a further four virtual cores, meaning it can effectively handle eight threads at once. There's also a solid Corsair 750W PSU, giving you plenty of headroom for overclocking and adding another GPU, 16GB of DDR4 memory, a high-speed M.2 SSD and an all-in-one liquid cooler.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | Cooler Master Cosmos SE | www.scan.co.uk | Issue 144, p41 | £116 |
| | Asus Maximus VIII Hero | www.overclockers.co.uk | Issue 146, p20 | £188 |
|  | Intel Core i7-6700K | www.scan.co.uk | Issue 145, p17 | £290 |
| | 16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M2A2666C16) | www.scan.co.uk | Issue 145, p24 | £59 |
| | NZXT Kraken X41 | www.overclockers.co.uk | Issue 138, p57 | £80 |
| | Corsair RM750i | www.scan.co.uk | Issue 146, p55 | £113 |
| | Seagate Barracuda 2TB ST2000DM001 | www.scan.co.uk | Issue 104, p75 | £55 |
| | Samsung SSD 950 Pro 512GB | www.ebuyer.com | Issue 149, p48 | £243 |
| | Microsoft Windows 10 Home Retail USB drive | www.scan.co.uk | Issue 146, p17 | £85 |
| | | | **TOTAL** | **£1,229** |

## Gaming PC

**The graphics card you'll need to play current games at their maximum settings at 2,560 x 1,440 and beyond.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | **2,560 x 1,440** AMD RX480 8GB **UPDATED** | www.overclockers.co.uk | Issue 156, p19 | £219 |
| | **4K** Asus Strix GeForce GTX 1070 OC **UPDATED** | www.ebuyer.com | Issue 156, p24 | £480 |

# Build a high-end 6-core PC

## Multi-threaded PC

**The parts you'll need to build a PC with serious power in multi-threaded software, such as 3D rendering apps, video editing programs and optimised distributed computing software. The kit list features a 6-core LGA2011-v3 CPU, which is overclockable using the motherboard and top-end cooler listed. Also supplied is 16GB of RAM, a super-fast M.2 SSD, 1TB of extra solid state storage and Asus' superb X99 Deluxe II motherboard.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | Phanteks Enthoo Luxe | www.eclipsecomputers.com | Issue 144, p53 | £132 |
| | Asus X99 Deluxe II UPDATED | www.scan.co.uk | Issue 156, p43 | £335 |
| | Intel Core i7-6850K UPDATED | www.overclockers.co.uk | Issue 156, p26 | £525 |
| | Asus Radeon R9 380 Strix 2GB | www.ebuyer.com | Issue 150, p48 | £154 |
| | 16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M4A2666C16) | www.scan.co.uk | Issue 136, p14 | £75 |
| | EKWB EK-Predator 240 Rev 1.1 | www.scan.co.uk | Issue 148, p30 | £170 |
| | Corsair RM750i | www.scan.co.uk | Issue 146, p55 | £113 |
| | Samsung SSD 950 Pro 512GB | www.ebuyer.com | Issue 149, p48 | £243 |
| | Samsung 850 Evo 1TB | www.cclonline.com | Issue 141, p51 | £255 |
| | Lite-On IHAS124-14 | www.shop.bt.com | Issue 99, p108 | £10 |
| | Microsoft Windows 10 Home Retail USB drive | www.scan.co.uk | Issue 146, p17 | £85 |
| | | | TOTAL | £2,097 |

## 4K gaming PC

**Replace the Asus Radeon R9 380 Strix 2GB with a single GeForce GTX 1070 graphics card to enable basic 4K gaming on this system, or take advantage of the Core i7-6850K's 40 PCI-E 3 lanes and add two GPUs.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | **4K** Asus Strix GeForce GTX 1070 OC UPDATED | www.ebuyer.co.uk | Issue 156, p24 | £480 |

# Build a mini PC

## Core components

**The parts you'll need to build either PC. This kit list gives you a solid PSU, 16GB of RAM, an overclockable Skylake CPU, an all-in-one liquid cooler and Windows 10 Home 64-bit. Also included is a graphics card that can play current games at their maximum settings at 2,560 x 1,440, and a high-speed M.2 SSD.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | Intel Core i7-6700K | www.scan.co.uk | Issue 147, p84 | £290 |
| | 16GB (2 x 8GB) Corsair Vengeance LPX 2666MHz | www.scan.co.uk | Issue 147, p84 | £59 |
| | Corsair H80i GT | www.scan.co.uk | Issue 147, p84 | £80 |
| | AMD RX480 8GB UPDATED | www.overclockers.co.uk | Issue 156, p19 | £219 |
| | Samsung SSD 950 Pro 512GB | www.ebuyer.com | Issue 149, p48 | £243 |
| | Seagate Barracuda 2TB ST2000DM001 | www.scan.co.uk | Issue 104, p75 | £55 |
| | EVGA SuperNova GS 550W | www.cclonline.com | Issue 146, p50 | £73 |
| | Microsoft Windows 10 Home Retail USB drive | www.scan.co.uk | Issue 146, p17 | £85 |

## Mini-ITX PC

**The parts you'll need to build a pint-sized powerhouse.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | Fractal Design Define Nano S | www.scan.co.uk | Issue 153, p22 | £60 |
| | Asus Z170i Pro Gaming | www.eclipsecomputers.com | Issue 147, p26 | £130 |
| | | | TOTAL | £1,294 |

## Micro-ATX PC

**The parts you'll need to build a mini PC that doesn't take up as much room as a full-sized desktop.**

| | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|
| | Fractal Design Arc Mini R2 | www.scan.co.uk | Issue 127, p46 | £70 |
| | Asus Maximus VIII Gene | www.overclockers.co.uk | Issue 147, p42 | £174 |
| | | | TOTAL | £1,348 |

# Cases

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **Budget ATX** | NZXT S340 | www.overclockers.co.uk | Issue 137, p54 | £53 |
| | **Sub-£100 ATX quiet** | Fractal Design Define R5 | www.scan.co.uk | Issue 137, p20 | £85 |
| | **Sub-£100 ATX performance** | NZXT H440 2015 Edition | www.overclockers.co.uk | Issue 154, p50 | £95 |
| | **Sub-£150 full-sized ATX quiet** | Nanoxia Deep Silence 5 | www.quietpc.com | Issue 144, p50 | £129 |
| | **Sub-£150 full-sized ATX** | Phanteks Enthoo Luxe | www.eclipsecomputers.com | Issue 144, p53 | £132 |
| | **Sub-£150 mid-size ATX** | Cooler Master Cosmos SE | www.scan.co.uk | Issue 144, p41 | £116 |
| | **Mini-ITX tower** | Fractal Design Define Nano S | www.scan.co.uk | Issue 153, p22 | £60 |
| | **Mini-ITX cube** | Fractal Design Core 500 | www.scan.co.uk | Issue 150, p20 | £53 |
| | **Micro-ATX** | Fractal Design Arc Mini R2 | www.scan.co.uk | Issue 127, p46 | £70 |

# Graphics cards

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **1,920 x 1,080 gaming** | Asus Radeon R9 380 Strix 2GB | www.ebuyer.com | Issue 150, p48 | £154 |
| | **2,560 x 1,440 gaming** | AMD RX480 8GB UPDATED | www.overclockers.co.uk | Issue 156, p19 | £219 |
| | **4K gaming** | Asus Strix GeForce GTX 1070 OC UPDATED | www.ebuyer.co.uk | Issue 156, p24 | £480 |
| | **Mini-ITX** | Asus GeForce GTX 970 DirectCU Mini | www.cclonline.com | Issue 150, p38 | £245 |

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STRIX-GTX970-DC2OC-4GD5 GAMING GRAPHICS
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# Power supplies

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **Mid-range 550W** | EVGA SuperNova GS 550W | www.cclonline.com | Issue 146, p50 | £73 |
| | **High-end 550W** | Super Flower Leadex Platinum 550W | www.overclockers.co.uk | Issue 146, p52 | £90 |
| | **Mid-range 750W** | Corsair RM750i | www.scan.co.uk | Issue 146, p55 | £113 |
| | **High-end 1.2kW** | Corsair Professional Series AX1200i | www.maplin.co.uk | Issue 111, p40 | £270 |

# Networking

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **Router** | Asus RT-AC68U | www.cclonline.com | Issue 128, p88 | £149 |
| | **Wi-Fi adaptor** | Asus PCE-AC68 | www.cclonline.com | Issue 128, p88 | £65 |

# Storage

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **Hard disk** | Seagate Barracuda 2TB ST2000DM001 | www.scan.co.uk | Issue 104, p75 | £55 |
| | **250GB SATA SSD** | Samsung 850 Evo 250GB | www.scan.co.uk | Issue 141, p51 | £75 |
| | **1TB SATA SSD** | Samsung 850 Evo 1TB | www.cclonline.com | Issue 141, p51 | £255 |
| | **High-performance M.2 SSD** | Samsung SSD 950 Pro 512GB | www.ebuyer.com | Issue 149, p48 | £243 |
| | **NAS box** | Synology DS216j | www.ebuyer.com | Issue 154, p28 | £136 |

# Monitors

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **24in monitor** | Dell U2414H | www.overclockers.co.uk | Issue 129, p43 | £189 |
| | **27in 2,560 x 1,440 FreeSync monitor** | Acer XF270HU | www.overclockers.co.uk | Issue 155, p46 | £380 |
| | **27in 2,560 x 1,440 G-Sync monitor** | Asus ROG Swift PG279Q | www.scan.co.uk | Issue 155, p48 | £670 |
| | **27in 4K G-Sync monitor** | Asus ROG Swift PG27AQ | www.scan.co.uk | Issue 151, p42 | £678 |
| | **27in 5K monitor** | Dell UltraSharp UP2715K | www.scan.co.uk | Issue 151 , p44 | £755 |
| | **34in ultra-wide curved G-Sync monitor** | Asus ROG Swift PG348Q | www.scan.co.uk | Issue 153 , p28 | £999 |

# Peripherals

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **Mechanical gaming keyboard** | Cooler Master MasterKeys Pro S (Pro L version recommended if you need a numeric keypad) | www.scan.co.uk | Issue 152, p44 | £110 |
| | **Premium mechanical gaming keyboard** | Corsair Gaming K70 RGB Rapidfire | www.scan.co.uk | Issue 154, p21 | £150 |
| | **Budget gaming mouse** | Cooler Master Xornet II | www.cclonline.com | Issue 149, p28 | £20 |
| | **Gaming mouse** | Logitech G402 Hyperion Fury | www.scan.co.uk | Issue 139, p53 | £41 |
| | **Ambidextrous gaming mouse** | Roccat Kova | www.cclonline.com | Issue 150, p28 | £50 |
| | **MMO gaming mouse** | Corsair Scimitar RGB | www.cclonline.com | Issue 150, p17 | £72 |
| | **Wireless gaming mouse** | SteelSeries Sensei Wireless | www.overclockers.co.uk | Issue 139, p61 | £100 |

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intel inside CHIPSET X99
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# Audio

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **PCI-E sound card** | Asus Strix Raid DLX | www.scan.co.uk | Issue 148, p28 | £150 |
| | **2.1 speakers** | Acoustic Energy Aego M | www.amazon.co.uk | Issue 142, p52 | £125 |
| | **Soundbar** | Razer Leviathan | www.overclockers.co.uk | Issue 142, p57 | £160 |
| | **Headset** | HyperX Cloud II | www.scan.co.uk | Issue 142, p46 | £68 |
| | **Surround-sound headset** | Asus Strix 7.1 | www.shop.bt.com | Issue 142, p43 | £126 |

# Systems

| | TYPE | NAME | SUPPLIER | FEATURED | PRICE (inc VAT) |
|---|---|---|---|---|---|
| | **Quiet gaming PC** | Scan 3XS Z170 Vengeance | www.scan.co.uk | Issue 151, p60 | c.£1,500 |
| | **Dream PC** | Scan 3XS Barracuda | www.scan.co.uk | Issue 145, p58 | c.£9,499 |
| | **Sub-£2,000 gaming PC** | Scan 3XS Z170 Vengeance 1080 GL | www.scan.co.uk | Issue 155, p62 | £1,950 |
| | **Mini-ITX gaming PC** | Chillblast Fusion Fury Nano | www.chillblast.co.uk | Issue 147, p56 | c.£1,619 |
| | **Premium mini-ITX PC** | Overclockers 8Pack Asteroid | www.overclockers.co.uk | Issue 154, p56 | c.£3,990 |
| | **Premium PC** | Scan 3XS X99 Carbon Fluid GL SLI UPDATED | www.scan.co.uk | Issue 156, p64 | £4,100 |
| | **Water-cooled PC** | Overclockers Infin8 Toxicity | www.overclockers.co.uk | Issue 150, p58 | c.£3,414 |
| | **Gaming laptop** | CyberPower Fangbook 4 SK-X17 | www.cyberpowersystem.co.uk | Issue 152, p30 | c.£1,909 |
| | **Thin and light gaming laptop** | Scan 3XS LG15 Vengeance G-Sync | www.scan.co.uk | Issue 153, p51 | c.£1,480 |

# Games

**Featured this month**

Inverse look p77 / Total War: Warhammer p78 / Total War: Warhammer DirectX 12 analysis p80 / Stellaris p82 / Overwatch p82 / Shadwen p84 / The engine room – Ink p86

RICK LANE / INVERSE LOOK

# WHY ARE THERE SO FEW WWI GAMES?

Following the announcement of Battlefield 1, Rick Lane ponders the dearth of games set in the Great War

The recent announcement that the Battlefield series would be visiting the trenches of World War I surprised nearly everyone. Not only did it completely buck the trend of military shooters pushing further into the future, but it also settled upon a conflict that first-person shooters, and indeed games as a whole, tend to avoid.

There are a couple of decent WWI games, such as last year's Valiant Hearts, or the online shooter Verdun, plus a smattering of flight simulators and grand strategy games. However, you could count on a hand the number of truly great WWI games that had recently passed through the digestive system of a bear.

Part of the reason for this is that WWI poses significant problems for games, particularly for first-person shooters. The bolt-action rifles and emplaced machine guns that formed the bulk of the war's small arms aren't particularly well suited to the kinetic twitchiness of first-person shooters. Soldiers battling along the Western front would famously walk rather than run towards enemy lines. Imagine doing that in Quake III.

> Bolt-action rifles aren't well suited to the kinetic twitchiness of FPS games

But even that explanation doesn't tell us why WWI is so rarely explored as a whole in gaming. The other reason, I think, lies more in modern ethical and ideological attitudes toward the Great War. In our culture, WWI is viewed as an utter catastrophe, wherein a combination of 20th century technology and 19th century imperialism led to an incomprehensible waste of human life. Our moral understanding of WWI is dominated by the elegiac poetry of Wilfred Owen and the tragicomic satire of Black Adder.

To use this desperately sad event in human history as a vehicle for entertainment seems sacrilegious. Unless you're making a dry strategy game about statistics and manoeuvres, or an unambiguous tribute to the fallen soldiers, it feels as though you aren't treating the war with the respect it deserves.

Is WWI deserving of this unique protection from creative exploration? The best answer is 'no more than any other war'. What makes WWI unique is neither the scale nor the circumstances of its horrors, but how our culture perceives those horrors today. All wars, from the Punic wars to WWII, are fraught with horror and atrocities, but we're more likely to focus on the tactical genius of Hannibal, or the endlessly fascinating character of Hitler. Only with WWI do so many people hold the tragedy of the conflict itself above all else.

That isn't to say that you should go off and write that musical set in Ypres you've been pondering, although perhaps you should! The point is that any creative work should be judged on its own merits, and the way with which it deals with a particular setting or topic is part of that package. In this respect, WWI is no more immune to creative exploration than any other conflict.

Battlefield 1 could crassly exploit the events on which it's based, but it could equally provide a unique new insight. Even in the trailer, the game appears to deal with aspects of the war that are rarely considered by our Flanders-focused perception, looking at fighting in both Asia and Africa. Indeed, with the war teetering on the precipice of living memory, it may end up being games such as Battlefield 1 that keeps its imagery alive. CPC

**Rick Lane is Custom PC's games editor.** @Rick_Lane

# Total War: Warhammer / £40 inc VAT

**DEVELOPER** The Creative Assembly / **PUBLISHER** SEGA / **WEBSITE** www.totalwar.com/product/total-war-warhammer

On the surface, Total War and Warhammer seem like perfect bedfellows. The notion of witnessing a pair of gigantic Warhammer armies streaming down the sides of a valley towards one another has occupied the dreams of many a strategy enthusiast. In truth, however, the two make for a challenging merger. Total War has always emphasised historically accurate battles played out in real time, whereas the ridiculous, impossible fantasy units of Games Workshop duke it out exclusively in rule-heavy, turn-based conflict.

In other words, Total War: Warhammer marks bold new territory for The Creative Assembly, but the studio has pulled it off with a beautiful blend of epic battles and the magical silliness of Games Workshop. It's a bold, brutal and spectacular strategy game, although it's sometimes daunting in its complexity and has little tolerance for failure.

It's also the most tactically diverse game in Total War's history. Released from the shackles of reality, The Creative Assembly has emphasised the differences between the available races on both the battlefield and the campaign map. There are only four available races at the start of your first campaign – the human Empire, the Orcs, the Vampire Counts and the Dwarfs – but each race is unique in terms of units, tactics and strategies.

Campaigns have story missions and specific goals that must be met

There are too many differences to list them all, but to give a few examples, the armies of the Vampire Counts consist entirely of undead units such as skeletons, zombies and wraiths. The Dwarfs, meanwhile, emphasise artillery and technological marvels.

The Orcs are pure aggression, with their ranks consisting of hulking orc warriors and towering giants. Lastly, The Empire has a traditional army of soldiers, archers and cavalry, although even these ranks contain flying Pegasus Knights and the almighty Steam Tank.

Yet more interesting than the raw units are the strategic quirks unique to each race. The Vampire Counts possess no missile units, for example, so they can't attack from range. However, they're also the only race that can raise the dead, essentially creating new units on the battlefield. Vampire Counts also never retreat. Instead, the units will take a certain amount of damage before crumbling into dust. They can swarm an opponent with a massive horde, but then very suddenly vanish into nothing.

It will come as little surprise that battles in Total War: Warhammer are stunning experiences; watching a giant tear through the ranks of your noble Imperial army is both awesome and devastating. Warhammer's tactics are further complicated through the introduction of Heroes and Magic. The former are incredibly powerful units who lead your armies. In previous Total War games, it was prudent to keep your army generals away from the thick of battle. However, Warhammer heroes are expected to lead by example, so a unit such as Karl Franz or Manfred von Carstein can keep an entire platoon of soldiers at bay for long periods of time. In addition, each faction has its own form of magic, wielded by powerful sorcerers on the battlefield. Spells such as a gust of unnatural wind, or a bolt of tactically designated lightning, can blast a gaping hole in the enemy line.

Changes to the Total War formula extend far beyond the battlefield too. Campaigns are no longer a straightforward case of occupying as much land as your objectives demand. Rather, they're more directed affairs complete with story missions and specific goals that must be met. The Dwarf campaign is defined by the Book of Grudges, a list of grievances against the Dwarfs that you, as Thorgrim Grudgebearer, must rectify in order to win. The Orcs are like sharks on the campaign map. Their armies must never stop raiding, pillaging and fighting, or the troops will begin fighting among themselves, suffering attrition. In addition, all factions must at some point deal with the threat of Chaos, a fifth faction that resides far in the North, and slowly creeps southwards, assimilating all in its path.

The sheer diversity of Total War: Warhammer even affects systems such as diplomacy and conquest. The Empire, for example, can only occupy cities of the Vampire Counts or other Imperial factions. When fighting Orcs and Dwarfs, you must settle for sacking or razing the settlement.

Furthermore, if your side is directly opposed to another race, as the Empire is set against the Vampire counts, then your diplomatic relations begin severely penalised, requiring serious negotiation if you want to avoid direct conflict.

All these changes are built on top of the iterations and additions that have slowly accumulated in Total War over the years – economy management, region-specific policies, population growth, public order and so on. It's a lot to absorb, even for a veteran. The complexity isn't a problem itself, but failure is harshly punished.

A single defeat in the field can cost you multiple regions and damage your economy for a dozen turns, as the enemy propels forward, spurred on by victory. It's a reflection of the uncompromising, cutthroat nature of Warhammer's world, but it can also be frustrating when expansion is so gradual and granular.

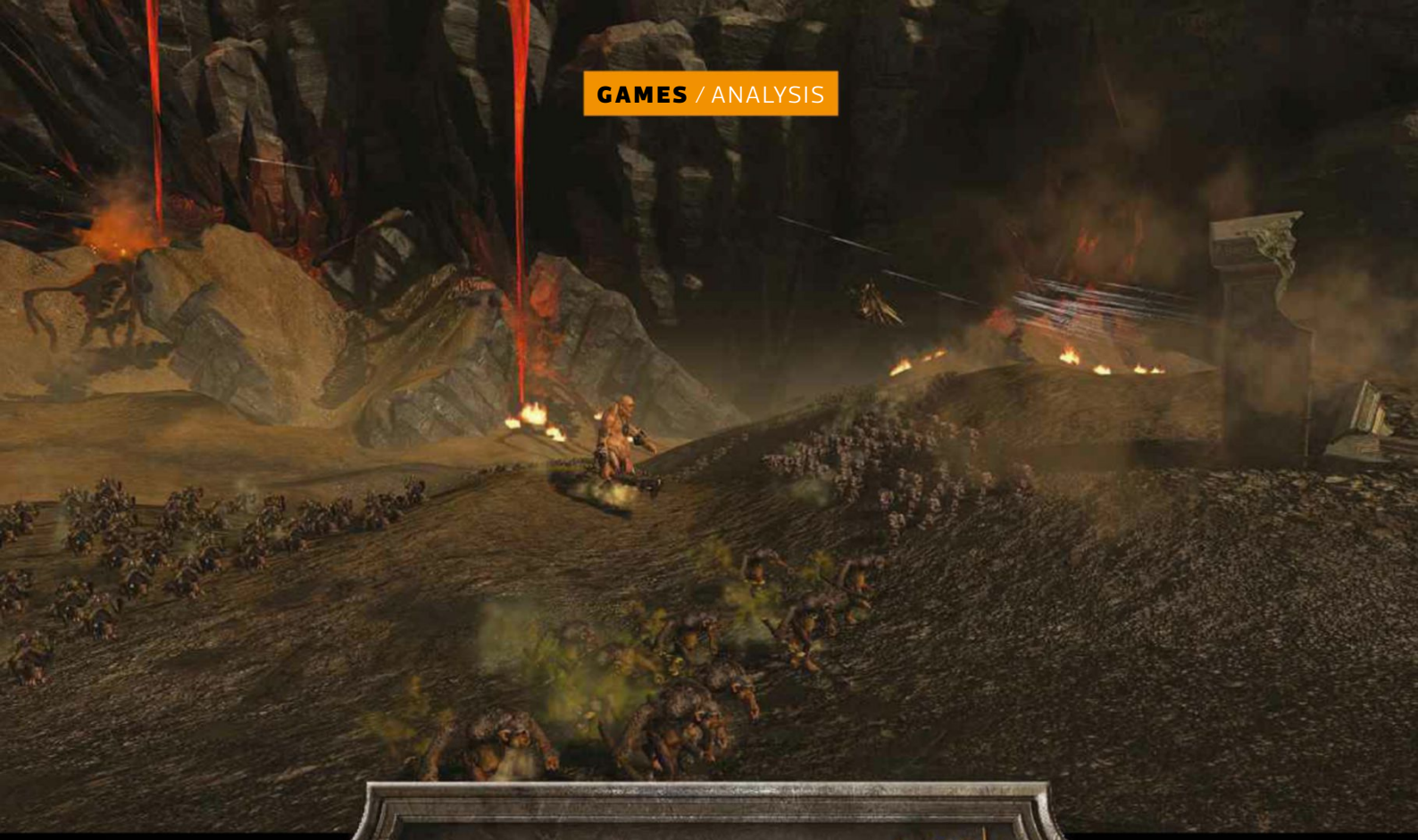
The way units are recruited and managed doesn't help either. Unit upkeep is expensive, so having two large armies on the field eats into your income. Also, unlocking higher levels often requires you to build multiple expensive buildings in the same region. Rather than getting a gradual dripfeed of new toys, your armies essentially have two distinct phases, possibly because the unit roster is fairly small for each faction, so the developer has complicated the path to recruiting them. Frankly, it's one complexity too many, and the building and economy side of the game should be facilitating war rather than hindering it.

Total War: Warhammer is a behemoth, and its gears of war perhaps turn a little slower than necessary. However, it's nevertheless a hugely welcome change in direction for the series. The more directed campaign goals improve the broader strategy considerably, and it offers the most stunning and surprising battles we've seen in Total War for years. It's a rambunctious, absorbing strategic titan, standing tall, if a little stooped, beneath the weight of its own ambition.

**RICK LANE**

**OVERALL SCORE**
**87%**

**/ VERDICT**
Big, loud, brash and cunning, Total War: Warhammer is the strategy mashup you've been waiting for, even if its gears of war turn a little slowly.



# TOTAL WAR WARHAMMER DIRECTX 12

AMD provides us with a DirectX 12 benchmark of the latest Total War game, getting us close to the metal. Ben Hardwidge tries it out

One of the big frustrations of being a knowledgeable PC gamer is knowing that your expensive box of cutting-edge tech is massively more powerful than the latest consoles, but you can't use all that power. Your graphics card might have loads more stream processors than the APU in the PlayStation 4, but then you have Windows clogging up the path. DirectX 12 aims to fix that, along with other new APIs such as Vulkan, enabling game developers to get 'closer to the metal', reducing the Windows overhead and improving performance.

DirectX 12 marks a very new approach for gaming APIs in that it doesn't introduce any new hardware features, and is even backwards compatible on earlier hardware. That isn't to say that new hardware won't be better optimised to take advantage of it though. DirectX 12 isn't so much about adding fancy new visual effects, but more about improving performance and reducing bottlenecks. AMD is confident that its hardware is better optimised for DirectX 12 than the competition, and it handed us an early version of a Total War: Warhammer DirectX 12 benchmark to prove it.

AMD isn't being entirely innocent here, of course. Total War: Warhammer is an AMD Gaming Evolved title, meaning the company was on hand to help optimise the game for its hardware, much like Nvidia does with its The Way it's Meant to be Played scheme. Also, as there's no DirectX 12 version of the full game yet, it's impossible to compare like with like. You can't force the DX12 benchmark to run in DX11 and compare performance. Plus, as it's early software, it also has a tendency to flake out. It wouldn't run on several of the graphics cards we tried (including some AMD ones). Basically, this benchmark will give us some ideas about DirectX 12 performance, but it isn't the be all and end all – we'll need to run more finished games on a variety of hardware to get the bigger picture.

The benchmark itself plays through a battle between the orcs and the Empire, with many units charging over the battlefield, beasts clashing in mid-air and a few changes in camera angles. It's clearly built to test

graphics performance in the chaos of large-scale battles. We ran the test at Ultra settings with MLAA enabled, and recorded the frame rates using Fraps, rather than using the in-game frame rate recorder.

## DirectX 12 benefits

There are a few ways DirectX 12 can potentially speed up performance. For a start, it has the ability to move gaming CPU workloads, such as draw calls, to multiple CPU cores, rather than simply loading them on one CPU core. This feature is potentially great for a game such as Total War: Warhammer, which has to draw lots of moving units simultaneously.

AMD is also confident that its DirectX 12 graphics pipeline is more efficient than that of its competitors, particularly when it comes to work that needs to be completed as quickly as possible. When performing such work, a game renderer needs to preempt how much time it will take to complete a task, from start to finish, so it can organise hardware allocation on the GPU efficiently. AMD reckons it has a more efficient way of preempting this type of work using asynchronous compute (where a GPU can use process both compute and graphics work simultaneously), using its Quick Response Queue system.

Nvidia has optimised preemption in the Pascal architecture too, but any current work needs to be saved before it can start a new job, which can slow down the process. With Quick Response Queue, these tasks get priority access to the shader engines on AMD hardware, and the use of asynchronous compute means the graphics rendering process isn't interrupted. Basically, by taking advantage of GPU compute and the ability to do it at the same time as graphics rendering, AMD can make the workflow behave in a parallel fashion, reducing latency and increasing frame rates.

Another benefit of DirectX 12 is explicit multi-GPU tech, which in theory makes it possible to combine the power of several GPUs, regardless of their manufacturer or spec. Sadly, we couldn't get the Warhammer: Total War DX12 benchmark to cooperate with any multi-GPU configurations we tried, including ones with identical AMD GPUs. We'll have to wait for the future to see how effectively this feature works.

## Performance

With all the usual caveats discussed earlier, the indications from this benchmark are good for AMD, even with older hardware. Running at 2,560 x 1,440, for example, our Sapphire Nitro Fury card was faster than the Asus Strix GTX 1070 (see p24). We also tried out the benchmark with AMD's latest Radeon RX480 (see p19), and while the benchmark crashed at higher resolutions, this mid-range card outperformed the GeForce GTX 980 and Asus Strix GTX 1070 at this resolution.

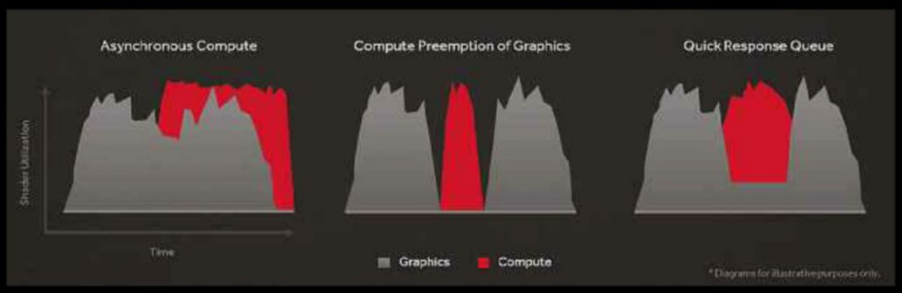
Interestingly, there was also very little difference between the 1080p results and 2,560 x 1,440 results across all the cards when you examine the minimum and average frame rates, but there was a stark difference in the maximums. For example, the GTX 1070's maximum of 76fps at 2,560 x 1,440 increased to 91fps at 1,920 x 1,080.

The indications are good for AMD at higher resolutions too. At 4K, the Sapphire Nitro R9 Fury's minimum of 35fps was significantly quicker than the 26fps from the Nvidia equivalent GPU – the GeForce GTX 980.

## Conclusion

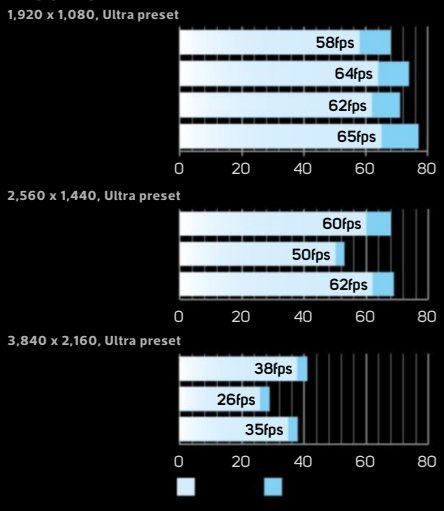
It's far too early to say 'AMD's hardware is better at DirectX 12 work than Nvidia's hardware', as there are far too many caveats with this benchmark, not least the fact that we couldn't get it to cooperate with several cards, plus there's no way to compare the results with the same test using DirectX 11. Nvidia could give us a benchmark for a 'The Way It's Meant To Be Played' title next month, and we could find that the opposite is true. Nevertheless, in this particular game in DirectX 12, AMD's hardware is clearly very efficient, with a Fury card significantly outperforming a GTX 980 card at 4K, and the RX480 even being quicker than a GeForce GTX 1070 at the only resolution we could get it working. We'll be very interested to see how the DirectX 12 battle plays out in the future. **OPC**

We ran the benchmark at Ultra settings, with MLAA enabled




AMD's Quick Response Queue tech aims to speed up preemption on time critical workloads

**RESULTS**




**Nvidia driver** 368.39 WHQL
**AMD driver** 16.5.3 beta (16.20.1035 on RX480)

# Stellaris / £30 inc VAT

**DEVELOPER** Paradox Interactive / **PUBLISHER** Paradox Interactive / **WEBSITE** www.paradoxplaza.com/stellaris

**OVERALL SCORE**
**65%**

**/ VERDICT**
Stellaris refines some of the clumsier elements of Paradox's games, but it also lacks the strategic diversity of the studio's best work.

In Stellaris, you assume the role of a newly fledged galactic empire, playing one of a selection of races that range from the Democratic nation of Earth to a race of despotic alien molluscs. The basic template is a standard 4X game; you gradually explore the galaxy, advance your space technology through research, build fleets of warships and attempt to defeat rival factions either through diplomacy or force.

The early game is brilliantly conceived, being designed to clearly explain the mechanics to new players while retaining their interest through story-driven exploration. A series of detailed tutorial missions take you through the basics of collecting important resources such as Energy Credits and Minerals, building space stations and colonising new planets.

At the same time, you must send out your Science ships to survey uncharted systems, triggering an eclectic blend of scripted and procedural events. Your Science crew will frequently discover anomalies that, when researched, result in new technologies, or strange artefacts that you must decide whether to investigate or leave alone. They'll also encounter a bevy of alien races, from primitive species you can choose to

observe and even elevate to spacefaring civilisations, to vastly powerful 'Fallen Empires' – ancient alien civilisations in gradual decline, which will nevertheless obliterate your pathetic upstart society should you provoke them.

Unlike most 4X games, in which you gradually paint the galaxy in the colours of your Empire, Stellaris restricts your ability to expand through a variety of mechanics. It limits the number of colonies you can control directly at any one time, and prevents you from expanding your borders too quickly through the game's third currency, Influence, which grows at much the same rate through the entire game.

# Overwatch / £40 inc VAT

**DEVELOPER** Blizzard Entertainment / **PUBLISHER** Blizzard Entertainment / **WEBSITE** https://playoverwatch.com

**OVERALL SCORE**
**93%**

**/ VERDICT**
Bright, fun and fiendishly clever, Overwatch is an unmitigated triumph from the slickest developer in the business.

Overwatch marks Blizzard's attempt to steal Team Fortress 2's multiplayer crown. It's a boilerplate arena shooter in which two teams vie for control of an objective, attempting to dominate a static control point, or taking turns to attack or defend a base. From this simple foundation, Overwatch builds layers of complexity through its ingeniously designed cast of playable Heroes.

Each of the 21 Heroes has a unique weapon, two or three 'abilities' with short usage cooldowns and one potentially game-changing ability with a much longer cooldown. These characters are roughly assigned to specific roles. Bastion, for example, is a robot designed to control a specific area of the map. His abilities enable him to transform into a very powerful gun-turret, or an even more powerful tank. Attacking Bastion head on will nearly always result in death for most other Heroes, but you can easily deal with him with a little forethought.

Another tank character, Reinhardt, carries an energy shield that can absorb a huge amount of damage and is big enough to protect an entire team. Alternatively, Pharrah is equipped with a rocket launcher and a pair of jump jets, enabling her to rain down fire on a fortified position. Both characters are effective counterarguments to Bastion, but they're also vulnerable to characters such as Tracer, a nippy mosquito of

The idea is to encourage players to interact with the game's colourful range of procedurally generated alien civilisations, all of which have different cultures and moral codes. Unfortunately, the ways in which you can interact with these species are disappointingly limited. You can ally with them, declare them rivals or go to war with them, but only the latter will provide any substantial progress towards your end goal of ruling the galaxy. The game is sorely lacking a variety of victory conditions for the different types of civilisations, meaning you have to go to war even if you're playing as a 'Pacifist' race.

There's fun to be had with Stellaris, and its procedurally generated galaxy offers a wide variety of emergent stories. Sadly, however, all these stories have the same ending, and the later game fails to live up to the early game's promises.

**RICK LANE**

a fighter able to teleport short distances and rewind her own timeline. As such, she's tricky to hit, which can cause real problems for a big, slow behemoth such as Reinhardt.

Such is the brilliance of Overwatch. Both teams are constantly deploying tactics and counter-tactics against one another as they attempt to complete the objective. Teams consist of only six players, so figuring out what trouble your team is in, and switching to the appropriate character to deal with it, can have a massive influence on the tide of battle. Even more remarkable is how easy Overwatch is to learn. Each character can be learned within a matter of minutes, and you'll be using them effectively within a round or two of experimentation. Overwatch is far less reliant on twitch skills than most shooters, even sporting a couple of characters who don't require you to aim at all.

Overwatch has plenty of personality, but unlike TF2, it lacks a definitive style or theme. Many characters revolve around cultural tropes or stereotypes, and some, such as Soldier: 76, are outright bland. The maps, too, while varied and fun to navigate, don't stick in the imagination in the same way as 2Fort. Those are the only complaints though. Overwatch looks splendid and runs smoothly with minimal online issues, while the characters and tactics that spin off them offer reasons to play for months.

**RICK LANE**

# Shadwen / £13 inc VAT

**DEVELOPER** Frozenbyte / **PUBLISHER** Frozenbyte / **WEBSITE** www.shadwen.com

Shadwen marks a significant departure for developer Frozenbyte, best known for its Trine series of charming 2D platformers. Shadwen is Frozenbyte's first fully 3D game, shifting the emphasis from jumping over obstacles to sneaking past them. Shadwen derives its name from its protagonist, a female assassin who embarks upon a long and perilous journey to murder the king of an oppressed fantasy realm.

During her mission, Shadwen comes across an orphaned girl named Lily, who's being harassed by a guard about stealing an apple. In an unusual demonstration of altruism, Shadwen deals with the troublesome guard. As a consequence, Shadwen becomes the girl's ward, despite being only a few days away from committing regicide.

This intriguing premise is one of several decent concepts with which the game experiments. For example, Shadwen is adept at avoiding the eyes of patrolling guardsmen, so the game instead emphasises using your abilities to clear a paths for Lily to reach the end of a level. Time freezes when you stay still, and you can rewind, so you can try different methods of killing or distracting guards.

Time freezes when you stay still, and you can rewind

Shadwen's best idea is the system that drives the relationships between its two central characters. Lily's personality is affected by Shadwen's actions. If the young urchin sees a dead body or witnesses Shadwen in the act of murder, she becomes 'horrified', affecting the story, but only if she directly witnesses these events. As such, you can be delectably devious when slitting guards' throats, by quickly hiding them in bushes and haystacks as Lily scurries past, essentially protecting her from your dark side.

Sadly, though, Shadwen is hampered by a lack of refinement. The potentially interesting story is ruined by bad writing and worse voice acting. The visuals are initially striking, but the constant regurgitation of the same level assets smothers any environmental diversity. The loose controls and sloppy animations also mean Shadwen lacks the precision that a stealth game requires.

The biggest problem, though, is the lack of evolution. Only one or two new enemies are introduced throughout the game, and while there are several gadgets available, they're all single-use items rather than fundamental new mechanics. The relationship between Shadwen and Lily never seems to progress narratively or mechanically either – they don't learn to work together or develop a meaningful bond. The entire game feels devoid of any stakes, like a heist movie that starts with the protagonist winning the lottery.

In short, Shadwen resembles an Alpha game that was released far too early. It isn't short of good ideas, but it needed another year in the oven to tighten up the mechanics, and bring some much-needed diversity into how the game looks and plays.

**RICK LANE**

**OVERALL SCORE**
**40%**

**/ VERDICT**
An interesting but ultimately unsuccessful experiment, you're better of slipping past this stealth game.

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80 Days doesn't just involve choosing lines from conversations. You also need to manage your inventory, balancing useful items with space

RICK LANE / THE ENGINE ROOM

# Ink

Rick Lane speaks to adventure game developer Inkle about its scripting language that expands the horizons of interactive fiction

From the reboot of Steve Jackson's Sorcery! series to 80 Days (a dynamic retelling of the classic Jules Verne story), Inkle Studios' highly ambitious interactive fiction projects are far removed from the usual interactive fiction fare. They're led by graphics, and they place strong emphasis on making you feel like you're playing a game, rather than simply choosing from branching lines of text.

'Right from the moment we formed the company, we knew we wanted to make flexible, narrative games,' says Joseph Humphrey, co-founder and lead programmer of Inkle. 'While a lot of games have branching, say, after a minute's worth of content, we wanted to make sure the player was interacting with the story every few seconds. To enable that, you need to create tools that can cope with that level of interactivity.'

To this end, Inkle created Ink, the studio's own scripting language, which forms the written basis for all its games. Essentially a form of middleware that can be paired with a graphics engine such as Unity, Ink is designed be more flexible and powerful than other interactive fiction software.

The earliest version of Ink was created by Inkle's other co-founder, Jon Ingold, while he was still a teenager. 'My brother had written a text adventure but it blew the size of the compiler we were using at the time, and I had this clever idea, that if you put the data in a format file and just added a bit of code that ran that format, it wouldn't explode the size of the compiler,' says Humphrey.

By the time Ingold had finished the compiler, his brother had lost interest in his game, but Ingold stuck with the idea, and over time Ink evolved into a more comprehensive, albeit rather baggy, scripting language. An early version converted bare bones text into JavaScript, which then evolved to converting said text into a JSON file format, and finally it converted it into Pearl; all this left the script with many idiosyncrasies.

'We took a step back and did a design pass on the language, which until then had just evolved crusts and barnacles, like a weird Galapagan tortoise, to exactly fit its niche. We ended up with something that has all the things I loved about Inkle 1, but it's much more robust and stable,' Ingold explains.

**Ink is a scripting language. The visual element of Inkle's games is provided by an engine such as Unity**

The current version of Ink is a declarative scripting language that works counter-intuitively to most computer programs. 'Generally speaking, there's no call stack.' Humphrey says. 'You don't go down levels, there's no structure to it at any given moment; if you're in the story, you're in one place in the story.'

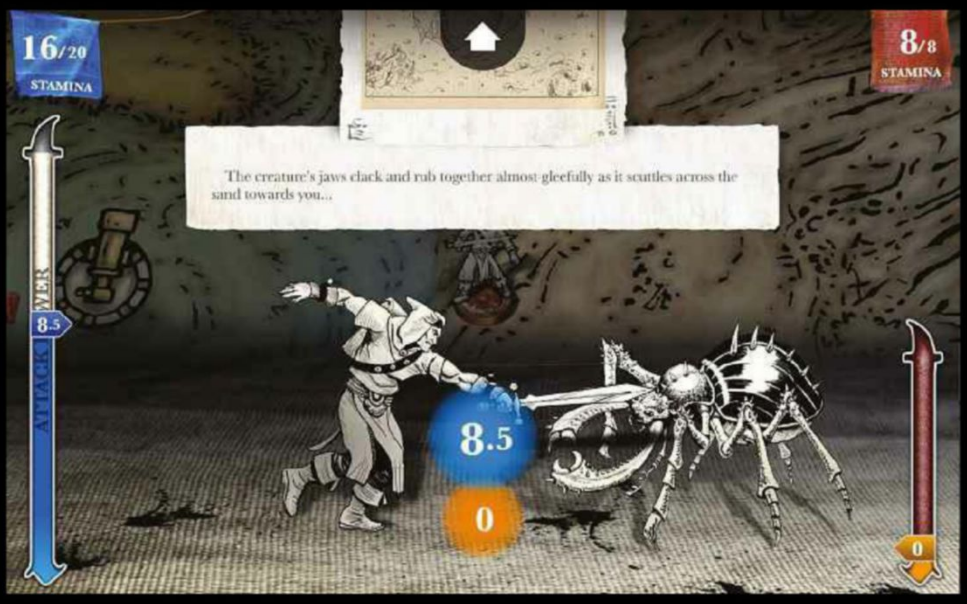
Ingold adds that 'most coders will look at that and say it's an incredibly dangerous thing to do, and it's destructive. But from the point of view of writing a story, it allows you infinite variability. You're not constrained to using any structures at any point; you can write what you like when you like'.

It may sound complicated, but the idea is to let interactive fiction designers concentrate on the writing, and have the scripting language do the hard work for them.

To that end, Ink has several unique features. At its simplest level, Ink has sections and subsections that can be linked together with 'goto' arrows, which Inkle calls 'knots' and 'stitches'.

Ink adds a feature called 'Weaves' to these knots and stitches, which enables writers to build intricate narrative branches as a straightforward cascade of indented points. In other words, they write out their choices sequentially as they would write standard dialogue, mark them appropriately, and Ink will recognise these choices and implement them accordingly. 'The writer doesn't even need to worry about whether they've stitched it all together properly, because they can be sure that it will start at the beginning and will hit the end,' Ingold says.

For its latest unannounced game, Inkle added a new feature called a 'Thread', which enables the designer to split the game into two parallel circumstances, which collapse into one another based on the player's choices. 'Essentially, you can start building games with lots of different bits of story running parallel that are assembled together on the fly, which interactive fiction doesn't normally do, but old text-adventures did quite a lot. You could be in a room with a variety of objects, and could interact with any object,' Ingold explains.




**Sorcery even has a combat system, narrated with lines of text of course**

Inkle points to Sorcery III as its most ambitious work so far. In Sorcery III, the player has access to beacons that can be pointed across the map, and you can explore an area within the beacon's light 1,000 years in the past. The player can then move in and out of the beacon's light freely. Consequently, the game must be able to adapt to whether the player currently exists in the present or the past. 'You might be in a location, steal something, run away from the guards, run through the beacon and the city gets ruined around you and the guards disappear. If you're on a lake in your boat, and you sail through the beacon, your boat might disappear and you'll end up swimming in the water,' Ingold says.

**Sorcery III's beacons let you explore the same areas of the map 1,000 years in the past**

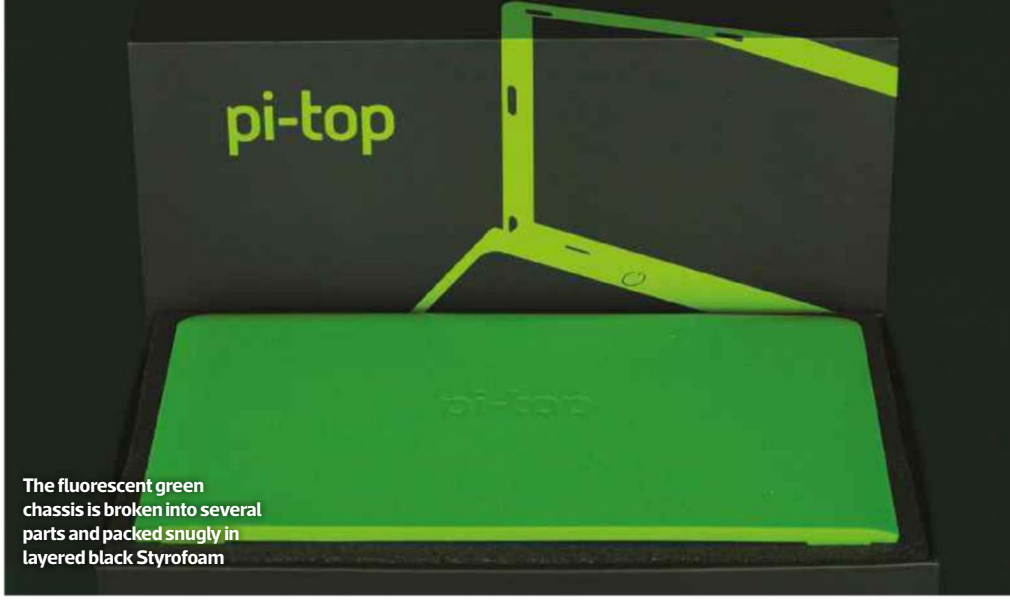
Such surprising and unexpected events are very similar to the kind of emergent play you would expect in an open-world RPG or grand strategy game, which is precisely the experience Inkle is trying to create. 'The goal is to make something that feels like an immersion/simulation game, but written from a very large corpus of extremely specific content, rather than a random hodgepodge of procedural generation,' Ingold says.

Ink has proved successful for the studio. 80 Days was voted Time magazine's game of the year in 2014, and the Sorcery series has increased in ambition with each release. However, Inkle is also interested in seeing great interactive fiction being written, so earlier this year it made Ink open source for everyone to use. Meanwhile, the studio is continuing to experiment with ways to expand the power of its scripting language.

'It does kind of open the door, the question of whether there are other formats and mark-ups that we haven't stumbled upon yet, which would afford different play structures. It's something to think about,' Ingold says. RPG

# Build your own Raspberry Pi Laptop

**A build-it-yourself laptop with a 12-hour battery life for under £300? Joe Martin tries building the Pi-top**



The fluorescent green chassis is broken into several parts and packed snugly in layered black Styrofoam

Launched as affordable bare bones microcomputers with an educational slant, the first Raspberry Pi boards offered some of the biggest bargains the computing world had ever seen. Since then, the Raspberry Pi has gone from strength to strength, spawning multiple hardware updates and forming the backbone for all sorts of modding projects.

The Pi's success has also given rise to a cottage industry of tech companies offering add-ons, extensions and upgrades designed to increase the Pi's potential. That's all well and good if you don't mind breaking out the soldering iron or if you have a specific project in mind, but it's also possible to build something a little more polished and traditional from the Raspberry Pi.

That's where London-based startup Pi-top enters the story. After raising nearly £200,000 from crowdfunding site IndieGogo in late 2014, Pi-top's first product is an eponymous build-it-yourself laptop built around the Raspberry Pi. There are two versions available – one includes a brand-new Raspberry Pi 3 and SD card loaded with a custom OS (more on that later), and one is aimed at people who already have a Raspberry Pi.

Whichever version you choose, Pi-top's promise is attractive – a sub-£300 laptop with a 12 hour battery life that functions as both a great everyday laptop and a launch pad for Raspberry Pi projects. It doesn't hurt that the Pi-top is one of the most visually pleasing laptops we've seen in a long time either, with a bright green angular shell that's sure to attract attention.

## DIY Pi, aye?

Out of the box, that fluorescent green chassis is broken into several parts and packed snugly in layered, black Styrofoam. The build-it-yourself adventure begins here, with cables sealed in anti-static bags, along with all the necessary standoffs and nuts. There's a pair of 1.25mm and 2mm Allen keys too, which are amazingly the only tools you'll need. The Pi-top's design means you can build your own laptop without even a screwdriver. It's one of the many advantages of the Raspberry Pi's diminutive all-in-one design.

We did notice a few minor issues when preparing to build the Pi-top, however. There's an empty space cut into the Styrofoam and some slight errata in the manual, for example. The reason is simply that the latest Pi-tops ship with a Raspberry Pi 3, which features on-board Wi-Fi, but older models supplied a Wi-Fi dongle and a Raspberry Pi 2. Neither the packaging nor instruction manual have caught up to this change just yet, but the only result is a bit of momentary confusion.

It's worth using a Raspberry Pi 3 model of the Pi-top though. It won't cost you any extra, and the Pi 3 has on-board Wi-Fi and Bluetooth, as well as a faster quad-core CPU (1.2GHz compared to 900MHz) and a VideoCore chipset (400MHz compared to 250MHz).

Earlier Pi-top models also used a 3D printed chassis, but the team recently switched to an injection moulding process. Part of the reason is that all manufacturing had previously been done in the UK, but as demand has increased, it's become difficult to print high-quality plastic in such large quantities. One Pi-top engineer told us the team would need ten industrial 3D printers, all printing around the clock – the move to a new process made better financial sense than setting up a factory in central London.

Happily, the injection moulded shells are sturdier and thicker than the 3D printed versions anyway. That's vitally important given the Pi-top's bare bones design – it's almost 100 per cent plastic and can feel more fragile than traditional laptops as a result. Photos of older models show the back of the screen glowing visibly through the lid and that the plastic was roughly scarred by the printing process. Injection moulding solves all these issues and results in a sleek, smooth finish that's significantly stronger.

## Building the Pi-top

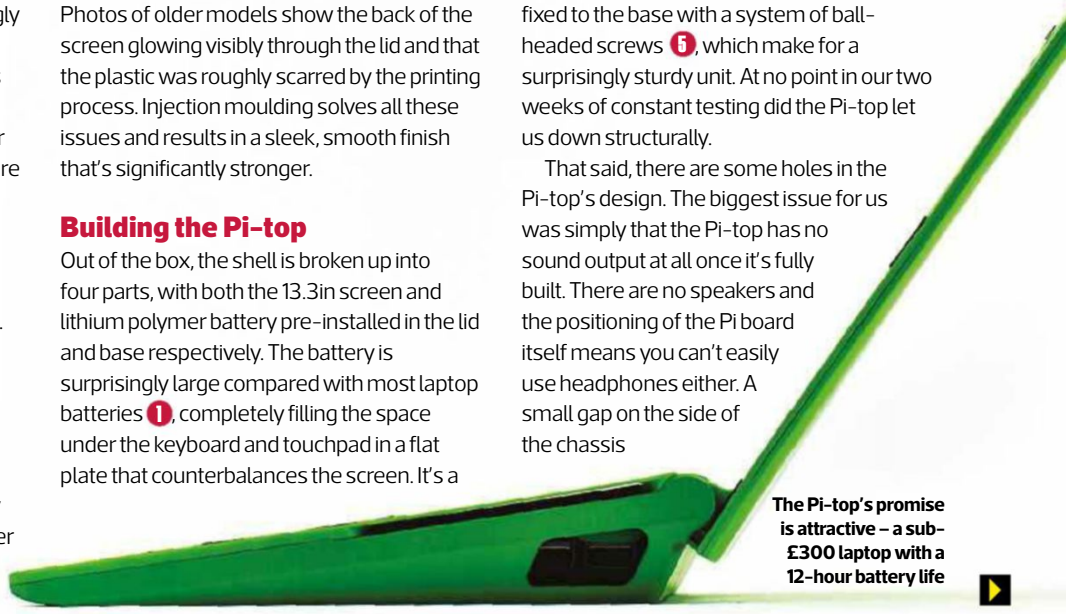
Out of the box, the shell is broken up into four parts, with both the 13.3in screen and lithium polymer battery pre-installed in the lid and base respectively. The battery is surprisingly large compared with most laptop batteries 1, completely filling the space under the keyboard and touchpad in a flat plate that counterbalances the screen. It's a clever design, making the most of the Pi's small size without adding any bulk. Between the size of the battery and the Raspberry Pi's modest power requirements, the Pi-top boasts an astonishing 10-12 hours of battery life – and our real-world tests hit the upper limits of that range.

Assembling the Pi-top is straightforward, and seasoned PC builders are unlikely to have any problems following the 23 steps to complete it. The Lego-like instruction manual does an excellent job of guiding you through the process (it's better than the manuals with most PC cases). The Pi-top lid and base slot together at first, with the custom hinge lining up in such a way that a single bolt on each side is all that's needed to keep it secure 2.

It's then just a matter of using standoffs to fix the Pi and Pi-top extension hub onto plastic rails below the screen 3. Magnetic rail covers on the Pi-top's underside can be easily removed to provide access and, while there's some tricky cable routing involved with the screen, the process is no more taxing than mounting a motherboard 4.

With the Pi firmly fixed on to the rails, the rest of the construction can be performed in a matter of minutes. The keyboard is then fixed to the base with a system of ball-headed screws 5, which make for a surprisingly sturdy unit. At no point in our two weeks of constant testing did the Pi-top let us down structurally.

That said, there are some holes in the Pi-top's design. The biggest issue for us was simply that the Pi-top has no sound output at all once it's fully built. There are no speakers and the positioning of the Pi board itself means you can't easily use headphones either. A small gap on the side of the chassis


The Pi-top's promise is attractive – a sub-£300 laptop with a 12-hour battery life

allows access to the USB ports, but even if you slide out the 'removable acrylic slice' 6 to get better access to the 3.5mm jack then you'll still struggle. We tried a few types of headphones and weren't able to make any of them fit.

Whether or not this is a critical problem comes down to your own perspective. If you're looking at the Pi-top as a fully functioning laptop replacement then lack of sound is definitely a significant issue. However, if you approach the Pi-top like any other Raspberry Pi project then it's not such a big deal – you just need to set up a speaker of your own or make a simple mod with a jack extension cable. Pi-top has its own add-on speaker module available to buy separately, but we found it easier just to use a set of Bluetooth headphones instead.

Add-on speakers aren't the end of the upgrade story either. The Pi-top's rails leave plenty of room for other modules and HATs, including a general purpose Pi-PROTO module designed for use in several of the Pi-top's coding tutorials.

Again, these accessories will be of limited appeal if you want the Pi-top to replace your everyday laptop, but if you're feeling adventurous then there's a lot of potential for you to explore through the wide range of sensors and upgrades available for the Raspberry Pi.

For us, the lack of sound wasn't an issue unless we wanted to watch movies. The Pi-top is never going to be a primary gaming machine and it's designed more for everyday work anyway. We *were* excited by the prospect of linking some USB-powered LED strips together and adding further razzle-dazzle to the design though.

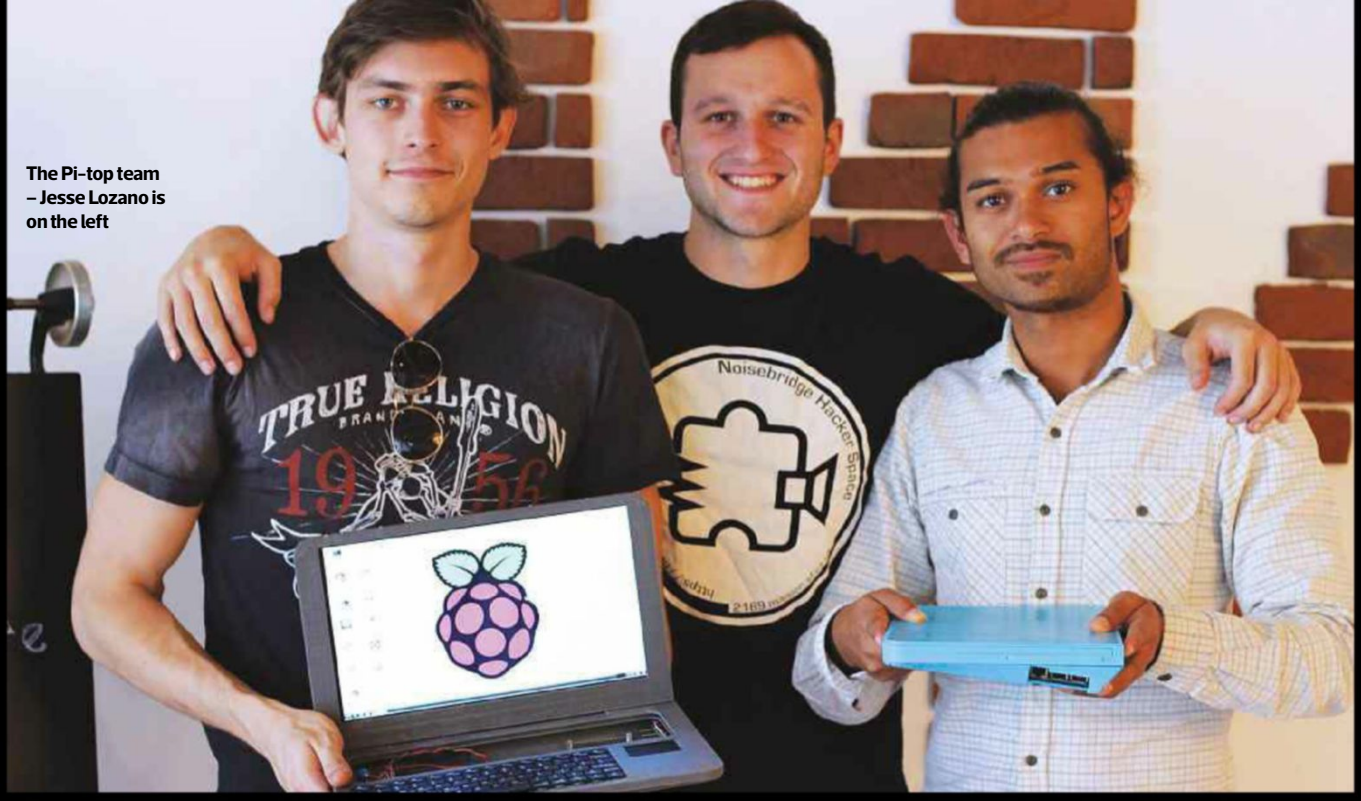
**Pi-top has its own add-on speaker module available to buy separately**

## Proof is in the pudding

With the Pi-top built in under 20 minutes, we were eager to boot it up and see how it performed 7 8. Sure enough, it worked perfectly thanks to a supplied 8GB SD card that has both Pi-top OS and Raspbian pre-installed.

The way in which these two operating systems interact is one of Pi-top's more unusual design decisions. Pi-top OS is, like Raspbian, a Debian fork that the Pi-top automatically boots at launch and has two different interfaces. The first is the default – a bright, colourful GUI that's clearly OSX inspired and meant for younger audiences. Users can log in to their Pi-top account, play with the bundled software and also try Pi-top's gamified learning and teach-yourself coding workshops.

At the press of a button, however, this GUI falls away and you can access either the standard Linux terminal or a different GUI that looks virtually identical to Raspbian. This GUI offers much more access to the usual




The Pi-top team – Jesse Lozano is on the left

# Meet the makers

## Pi-top founder Jesse Lozano discusses launching a tech company, 3D printing and teaching kids to code

**CPC: What was your inspiration?**
**Jesse:** My co-founder Ryan and I were both Raspberry Pi fans and we found that educators and makers wanted a device that could be used to learn how to *create* hardware, not simply consume it. Everything grew from there.

**CPC: The first Pi-tops were 3D printed. Why change?**
**Jesse:** In the beginning, it was just Ryan and I in a living room, building prototypes. 3D printing was the only way to affordably iterate, but we always planned to use injection moulding, as it gives the best finish. You can still 3D-print your own case but it's an advanced project.

**CPC: How has the Pi-top design changed?**
**Jesse:** There's a huge amount of change when you take a prototype and make it manufacture-ready. Most of the changes were mechanical or structural, such as the custom hinge design and the snap-together circuits. All these changes result in hardware that's easier to make.

**CPC: Pi-top OS has a strong educational focus. Why?**
**Jesse:** We knew the Raspberry Pi was a fantastic educational tool, but turning it into a laptop transforms the humble Pi into an all-in-one computing and STEM (science technology, engineering and mathematics) device that's easy to deploy in schools. That's a major reason why educators and schools are so interested in Pi-top as an educational tool. On a personal level, we're passionate about creating affordable hardware that can deliver educational content in the classroom. We believe computing is the great equaliser, and we want to give every student truly equal access.

**CPC: How do you think educational technology will change over the next few years?**
**Jesse:** Educational technology is going through amazing changes. The Raspberry Pi is just the beginning for hands-on STEM learning in schools. The physical side of computing in the classroom will become much more widespread with the introduction of complementary devices such as the BBC Micro:Bit, which makes for fantastic entry-level hardware for students before they move to more capable platforms.

**CPC: What's been the biggest challenge?**
**Jesse:** Building a hardware company is one of the most challenging pursuits you can choose – you have to do it 100 per cent correctly, with no margin for error. It's not like software, where you can issue a fix later. You have to consider timelines of research, software, logistics, fulfilment and marketing.

Organising all these areas has been very difficult – you never realise just how much work goes into hardware until you do it yourself. My best advice for others thinking of going down a similar route would be to make sure that you want to dedicate your life to hardware, because that's what you're signing up for!

**CPC: What does the future hold for Pi-top?**
**Jesse:** We're growing fast. In less than two years, we've grown to a team of 25 people, moved into a large office in London and taken on investment just so we can keep up with demand.

We've also now shipped the pi-topCEED, which is a £99 desktop version of the Pi-top, so we'll be focusing on content for that. We want to make sure our users have thousands more hours of content from which to learn.

Lozano says the Pi-top team is 'passionate about creating affordable hardware that can deliver educational content in the classroom'

**The bright, colourful Pi-top GUI is aimed at younger audiences, but you can also access a standard Linux terminal or a different GUI that looks virtually identical to Raspbian**

Raspberry Pi features and, while it's an unusual setup, it basically offers the best of both worlds. The fact that there's a simple OS shell for kids and another more powerful option for grown-ups may make Pi-top uniquely appealing as a family laptop.

The distinction between the two audiences shows that Pi-top's focus is clearly on the educational market. In addition to the usual Raspberry Pi stalwarts – Minecraft, Scratch, Chromium and Libre Office – the Pi-top is also bundled with its own software. The biggest package is CEEDUniverse, a crafting and exploration game designed to teach you Python.

CEEDUniverse, like Pi-top OS, is a work in progress though. It's playable and fun, but it's still in a state of flux and pretty rough around the edges. Updates for both the game and the OS came out during our review period, which is a good sign in terms of on-going support but it's still a replacement for actual polish. It also didn't help that these updates were often needed to fix fundamental issues, such as not being able to log in.

It's an entirely different story for the Pi-top's physical design and build quality, though, which is nothing short of excellent considering the low price. Despite being made of plastic, the Pi-top is surprisingly resilient, holding up excellently to several days of being carried around and used for our work. After a fortnight of solid use, the Pi-top still looked, felt and performed just as well as it did after initial construction.

In fact, over time, we even found the Pi-top becoming our laptop of choice for tasks such as browsing the Internet and writing. The long battery life was definitely a factor here, but so was the decision to place the touchpad to the right of the keyboard. It's admittedly a rather baffling design at first glance, but it pays dividends in terms of ergonomics – there are no more uncomfortable wrist angles when you're sitting with it on your lap. Instead, you can just grab the side of the Pi-top and control the mouse with your thumb.

Amazingly, the keyboard doesn't suffer for its small size either. The keys are light and responsive enough that, after a day of acclimatisation (most of which involved learning not to hit Shift instead of Enter), we were typing at normal speed.

## Play with your food

While the Pi-top certainly held up well for everyday use, there's no getting around the fact that the Raspberry Pi 3 is still underpowered compared with regular PCs.

The Pi-top is great when you're cruising the Internet or replaying The Secret of Monkey Island in ScummVM, but it starts to chug if you open too many tabs or try to run modern software. There's still a surprising amount you can accomplish with the Pi-top, however.

In order to get a feel for the performance the Raspberry Pi 3 can offer, we ran two simple benchmarks – both using SysBench. Originally developed in order to test suitability for MySQL databases, SysBench nevertheless offers decent at-a-glance performance data and is the same tool we used to stress the original Raspberry Pi models at launch. In a nutshell, the Raspberry Pi 3 didn't disappoint. It turned out to be almost four times more powerful than the first Raspberry Pi Model-B on every count. SysBench's RAM test also had the Pi 3 coming out on top – it took the Pi-top less than a second compared to the original Pi's six seconds.

What this means in real-world terms is that the Raspberry Pi 3 (and, by extension, the Pi-top) is perfectly suited to acting as an on-the-go game emulator if you can overcome or overlook the lack of sound. Using software such as RetroPie (**https://retropie.org.uk**) we were able to emulate older consoles, such as Nintendo's Game Boy, without trouble. The Pi 3 held up well with most PlayStation 1 games too, although the frame rate dipped slightly in a few.

## Fit for a king?

The Pi-top offers an excellent way to get beginners interested in building PCs or coding. The design is geared towards this goal and, despite some rough edges, it fulfils the purpose brilliantly.

Even better, the Pi-top also functions well as a great general-purpose computer. It can't go head-to-head with even a standard cheap laptop in terms of performance, but the excellent battery life and low cost more than compensate for this shortfall if you can temper your expectations. If you're looking for an everyday laptop that you can use for work, browsing and playing old games then the Pi-top is an exciting and affordable alternative to other laptops.

Yes, you do have to cope with some significant setbacks in terms of the lack of sound, but we're confident **Custom PC** readers can rise to the challenge thanks to the Pi's upgradability. The Pi-top is available for £210 inc VAT from **www.pi-top.com**, and comes with a Raspberry Pi 3 and an 8GB micro-SD card. CPC

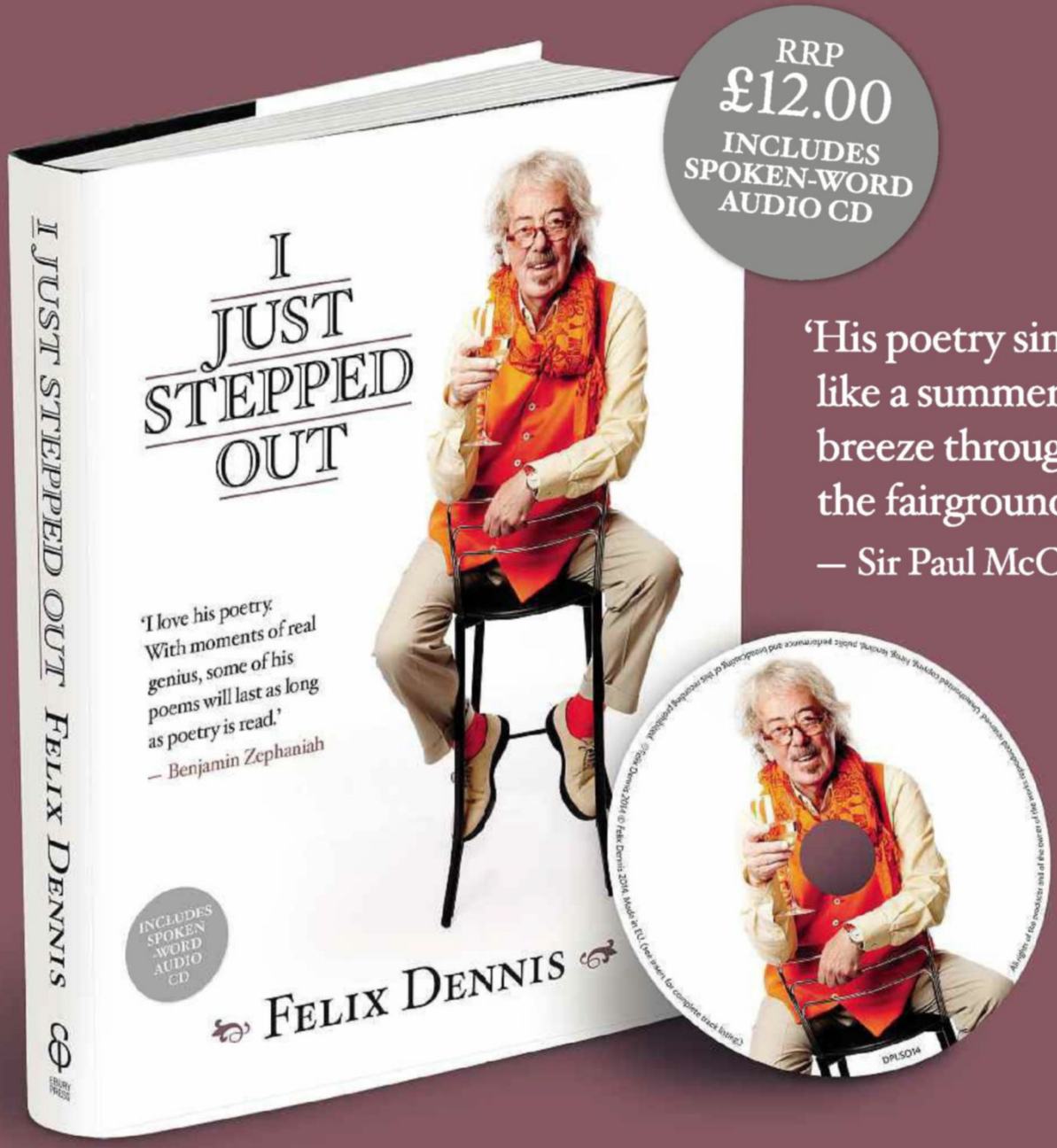
## Overclocking the Pi-top

Overclocking a modest little machine such as the Pi-top might seem eccentric, but if you want to get the absolute maximum performance out of your Pi, especially if you want to smoothly emulate 3D games, then it may well be worth a try. Bear in mind, though, that the Raspberry Pi 3 doesn't officially support overclocking. There's a lot of variation at the silicon level and even modest overclocks can prompt different behaviour between supposedly identical machines. Any changes are performed at your own risk.

If you do want to give overclocking the Pi 3 a go, however, it's a pretty straightforward process using the /boot/config.txt file – and we've broken down the most popular variables for you. Even if you're going to make modest tweaks to the CPU or memory, though, you'll want to attach heatsinks to the board. Kits are available online from most Pi resellers.

| | |
|---|---|
| **arm_freq** | Controls CPU speed in MHz |
| **core_freq** | Controls GPU speed in MHz |
| **sdram_freq** | Controls RAM clock speed in MHz |
| **over_voltage** | Controls core voltage in 0.025V steps |
| **over_voltage_sdram** | Controls RAM voltage in 0.025V steps |

# I JUST STEPPED OUT

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# DEVELOPING FOR VR

Developing VR games presents lots of new challenges, from limited physical space to creating realistic fighting. Rick Lane speaks to Hugh Hancock about Left Hand Path, a VR fighting game inspired by Dark Souls, to find out how you solve these problems

Once the butt of industry jokes, virtual reality is now very real and extraordinary to behold. Despite there being multiple headsets on the market, however, the games and applications currently available are still in their infancy. The focus so far has been largely on how well the technology works, rather than how we'll use it. As a result, many companies are still figuring out what works and what doesn't.

One such developer is Hugh Hancock, one of the original founders of www.machinima.com, and director of Machinima films such as Bloodspell and Death Knight Love Story. Having spent most of his career using game technology to make films, Hancock recently switched to full-blooded game development after a transformative experience with the HTC Vive.

'I'd pre-ordered the Vive consumer edition because I thought what the hell, it's interesting. But the day it turned up, I was hideously busy, so it sat there in the hall,' says Hancock. 'Eventually, I thought no, this is silly, I need to actually take this thing out and test it. So I took it out, set it up, played with it for two hours, came out and thought okay, this is what I'm doing for the next five years. It was literally that dramatic.'

Spells are designed to have a strong sense of physicality

Inspired, Hancock immediately set about building a game of his own. Three months later, he released the Alpha build of Left Hand Path, a first-person RPG heavily influenced by Dark Souls. Players assume the role of a mage who casts spells by drawing runes in the air with their hand, and explore a shadowy fantasy realm populated by huge, tough monsters.

Like Dark Souls, Left Hand Path is a combat-focused RPG. Unlike Dark Souls, though, the emphasis is on magic rather than melee combat. 'If you try swordplay in VR, you're on a hiding to nowhere because it's terrible; you can't parry,'

Players assume the role of a mage who casts spells by drawing runes in the air with their hand

Hancock points out. 'You end up with Wii-quality sword fighting, so I dropped that idea pretty quickly.'

Nevertheless, Hancock was still intrigued by the idea of engaging the player in physical fighting, which is where the magic idea originated. 'You have a staff and a hand. You draw in the air with your hand, it forms a glowing trail as you draw and, if you form the right arcane symbol, fire will fly from your staff, or the ground will open up,' he says.

It's an enthralling idea, but games such as Black & White have experimented with gesture recognition before, and the results were mixed. Hancock points out that this system was with the mouse, whereas in the Vive, you draw with your hands. 'Drawing in the air is just perfectly natural,' he says. The main problem right now is that the available gesture recognition software isn't fully up to the job.

'All existing gesture recognition algorithms I found are based on the idea that the gesture is 2D, because normally you're drawing on a screen or a touchpad,' he says.

The other major obstacle in developing Left Hand Path, and indeed any VR game, is the limitations of physical space. It's simply not possible to walk around a game world as you would walk in real life because, eventually, you're going to be limited by your home's walls and furniture. How, then, do you go on an epic fantasy adventure within the confines of your home?

'Most Vive games get around this issue by having teleporting,' Hancock explains. 'If you want to look at a book or a table, for example, but it's 40ft away, you'll point at a controller and select a point near that table where you want to move, and the game will then effectively move your entire play area over there, so you can walk over to the table and pick it up.'

The problem with this solution is that usually breaks your immersion, but one clear advantage that Left Hand Path has over other games is that you're playing as a wizard, so teleporting fits naturally within the game world. In fact, Hancock is adopting teleportation as a core game mechanic, effectively using it as a replacement for Dark Souls' rolls and dodges. Players can time their teleports to evade enemy attacks, then counterattack from a different angle by casting one of their spells.

VR development also transforms seemingly trivial game dev jobs into massively important considerations. When gaming on a monitor, a stuttering frame rate is inconvenient and unappealing. In VR, sudden frame rate drops will make the player feel physically sick. Hence, it's absolutely crucial to maximise performance. 'Baking lighting suddenly becomes a really big deal,' Hancock says.'

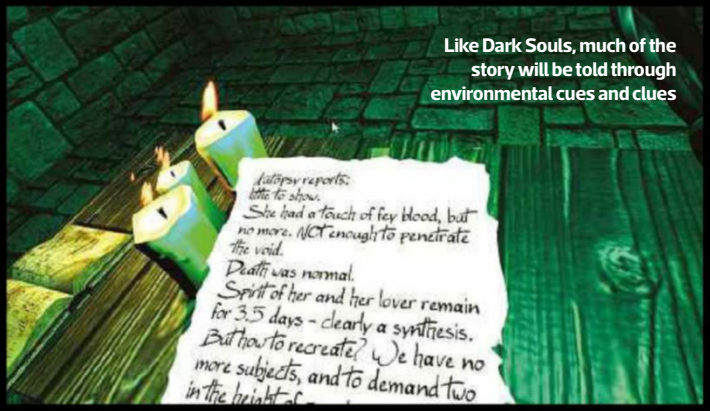
The other major consideration is the game menu. Having a splash screen suddenly appear in front of the player's eyes is both extremely disorientating and functionally next to useless. There are plenty of questions about how to design an interface in VR, but currently few answers. 'No one has any idea how to design a VR interface at the moment,' Hancock says. 'Does the menu appear? Is it attached to your face? Is it attached to your hand? Is it in the game world? What happens if you step forward and it goes through something? How do we track it? How should we interact with it; should we grab it, grip it, point at it?' It's a major problem with no obvious solution.'

Although the game is called Left Hand Path, Hancock has designed the game so that players can switch the control scheme to their dominant hand

Although these issues need to be resolved, we also shouldn't neglect the advantages of VR. In particular, Left Hand Path takes advantage of the sense of scale that VR offers by varying the size of its enemies. 'It doesn't make that much difference, even in an FPS, if a character is a little shorter or taller than you. You don't really feel it. But in VR, you feel scale so much. It's a big deal,' Hancock points out. 'The difference between something 5ft tall coming at you, and something 8ft tall leaping out of the shadows towards you is really spectacular.'

Indeed, although Left Hand Path is in the early Alpha stages, the response to it has been powerfully positive. Most VR games are small experiments that last little over an hour, but Left Hand Path already offers several hours worth of content.

The VR market is still fairly small, with around 50,000 active HTC Vive users, but it's only going to continue to grow, as the price of hardware drops and developers begin to figure out how to navigate the new challenges for building games. Hancock also urges experienced game developers to get involved. 'If you already have a solid background in all the disciplines in game development, then VR is surprisingly accessible. It's like making a 3D game, but better. Quite a lot better.' GPG



GARETH HALFACREE'S

# Hobby tech

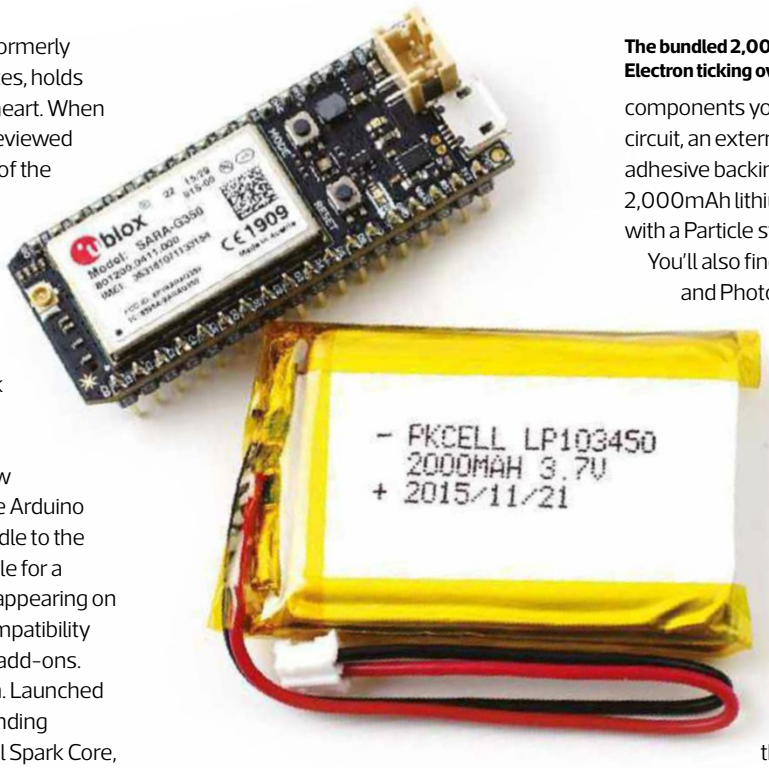
The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino and Android to retro computing

## REVIEW
## Particle Electron

Particle, the company formerly known as Spark Devices, holds a special place in my heart. When I first acquired the Spark Core, reviewed back in Issue 132, it offered one of the simplest and cheapest ways to run Arduino code on a teeny-tiny microcontroller with embedded Wi-Fi, and remains one of the most useful tools in my box of bits.

A rebrand later, and the Spark Core is known as the Particle Photon. It's also under threat: the ultra-cheap ESP8266 is now programmable directly from the Arduino IDE and, while it can't hold a candle to the Photon's feature set, it's available for a fraction of its price and already appearing on Arduino Uno-like boards for compatibility with existing Shields and other add-ons. Particle's answer is the Electron. Launched following a successful crowdfunding campaign, much like the original Spark Core, the Electron aims to do for GSM-based mobile communications what the Spark Core did for Wi-Fi.

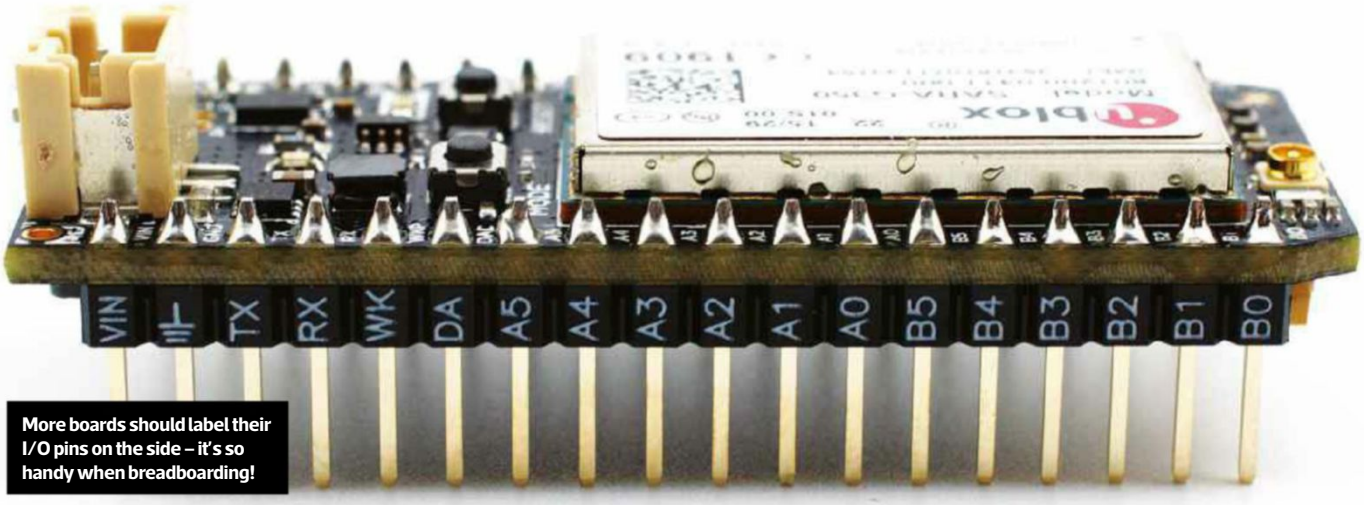
Opening up the resealable plastic packaging – a major upgrade from the Spark Core's old cardboard box – reveals the Electron. It looks like a longer version of the Photon, preinstalled on a compact solderless breadboard with a diagram for a simple circuit on top. You'll also find all the components you need to complete said circuit, an external PCB antenna with adhesive backing, a micro-USB cable and a 2,000mAh lithium polymer battery, along with a Particle sticker as an added bonus.



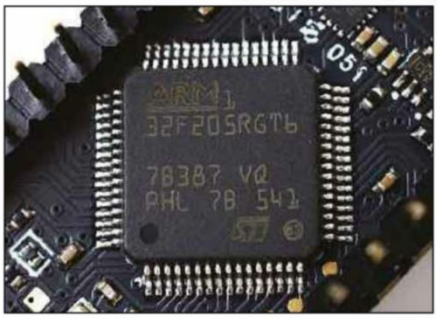

**The bundled 2,000mAh battery should keep the Electron ticking over in the field**

You'll also find a SIM card. Unlike the Core and Photon, the Electron doesn't use Wi-Fi for communications; instead, it includes a GSM mobile radio, connecting via 2G or 3G networks depending on which model you've purchased. The SIM card is for Particle's own service, which is available globally – for a $2.99 US (tax-free) monthly fee (around £2.05), you get 1MB of data with additional megabytes costing $0.99 (around 68p) thereafter. For the first three months, your first 1MB is free.

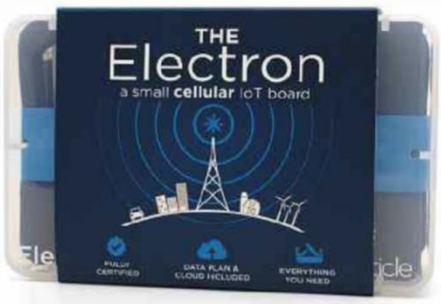
If you're used to getting a few gigabytes free with your PAYG SIMs, 1MB might sound stingy, but Particle points out that it's perfect for projects that send a few thousand



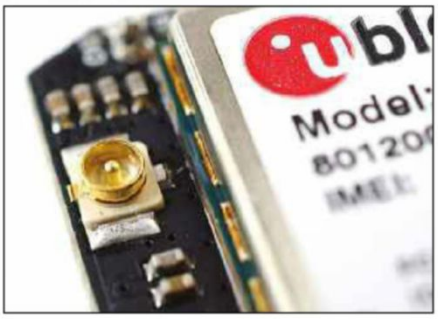

More boards should label their I/O pins on the side – it's so handy when breadboarding!




A 32-bit ARM microprocessor provides the Electron's brains




The Particle Electron comes as a surprisingly complete bundle, in an attractive reusable plastic box



A small UFL connector allows the external PCB antenna to be connected to the Electron

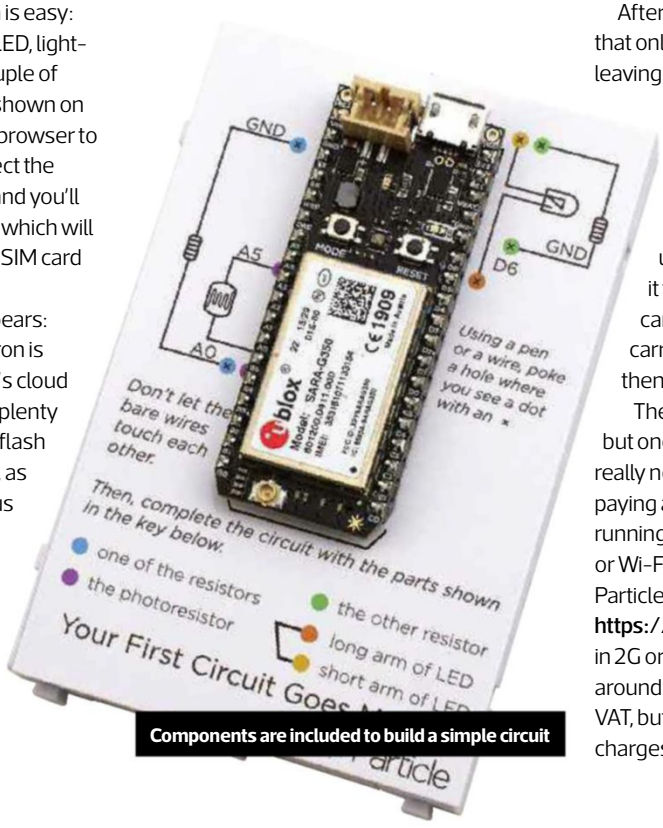
messages a month to the company's cloud platform, such as remote environment monitors, burglar alarms, entry systems and so on. Sure, it's not going to cut the mustard if you're looking to stream live video or audio, but the Electron is almost certainly the wrong choice of device for these projects anyway.

Getting started with the Electron is easy: insert the bundled components – LED, light-dependent resistor (LDR) and a couple of resistors – into the breadboard as shown on the circuit diagram then point your browser to **https://docs.particle.io/start**. Select the Electron from the options shown, and you'll be taken to a getting started guide, which will allow you to add an Electron with a SIM card to your Particle account.

Here's where the first niggle appears: like the Photon and Core, the Electron is designed to tie heavily into Particle's cloud infrastructure. This setup provides plenty of power and the ability to edit and flash code to remove devices wirelessly, as well as easy integration with various services such as If This Then That.

However, you're also expected to stay within the ecosystem, including using Particle's SIM card rather than one with a larger data allowance, and ensuring that this SIM is registered to your account and that you have a valid payment method for the line rental and data usage charges.

That said, unlike a Wi-Fi device, a GSM device will always need a carrier, so you're going to be paying someone and it might as well be Particle. If you're building a project for use indoors, the Photon has no running costs.




Components are included to build a simple circuit

However, the Electron shines when you're planning to use it away from civilisation, and the bundled battery – which is automatically charged when the Electron is connected to USB power, making it easy to add solar charging to your project – is a very neat touch indeed.

After registering the SIM card – a process that only works with Particle's own SIMs, leaving anyone wanting to use a third-party SIM looking into hacky workarounds – the Electron is added to your Particle account. Code can be written in the web-based IDE and sent to the Electron wirelessly and, thanks to its use of GSM signals, there's no need for it to be near a mobile base station: if you can get a mobile signal from Particle's carrier in your country – O2 in the UK – then your Electron should be accessible.

The Electron is an easy device to love, but one which requires a little thought: you really need to decide if your project is worth paying a couple of quid a month to keep running, or whether offline data collection or Wi-Fi piggybacking is a better option. The Particle Electron is available now from **https://store.particle.io** priced at $49 (US) in 2G or $69 (US) in 3G variants, equating to around £40 and £57 respectively including VAT, but excluding any customs clearance charges you may have to pay.

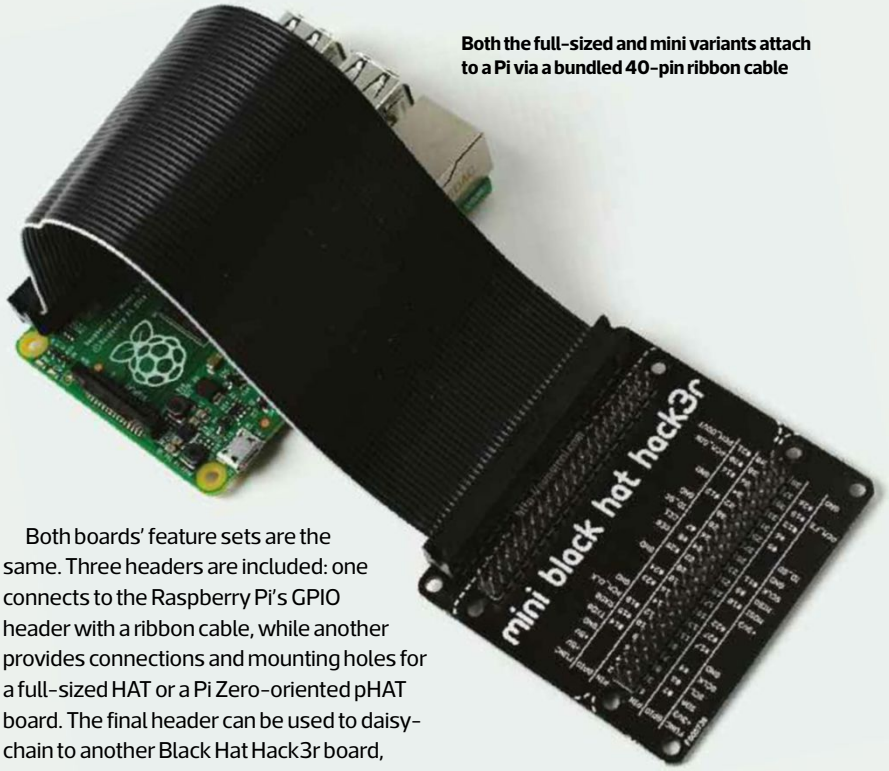
## REVIEW

# Pimoroni Black Hat Hack3rs

Sheffield-based Pimoroni's circuitboards are always attractive and clean, even when there are absolutely no active components, as with the Black Hat Hack3r family. The original Black Hat Hack3r was invented to solve an internal problem: Pimoroni was designing Hardware Attached on Top (HAT) add-on devices for the Raspberry Pi, but debugging them was a pain. Each one had to be installed on the top of the GPIO header, and the only option for attaching test leads was to include a larger, through-hole pin header, which meant testing a different, hand-built design to the final mass-produced version.

The solution was simple: an interposer board that sits between the Raspberry Pi's GPIO header and the HAT to be tested, breaking out all 40 of the pins for easy testing and observation, or even for reverse-engineering. Better still, much like the 8-bit port expanders of the 1980s, it's even possible to chain multiple Black Hat Hack3r boards to attach multiple HATs to a single Pi – providing, of course, that the HATs in question play nicely with each other on whatever bus they use. The Black Hat Hack3r also makes it easy to use spare pins for other non-HAT hardware device, such as LEDs or switches, and to move HAT hardware elsewhere in a project case via the bundled ribbon cable.

The Black Hat Hack3r stood alone for a while, but then the £4 Raspberry Pi Zero came along. Featuring a new, smaller footprint, the Zero is technically compatible with existing HAT hardware and the original Black Hat Hack3r, but Pimoroni opted to design an entirely new interposer board specifically for the Pi Zero, dubbed the Mini Black Hat Hack3r.



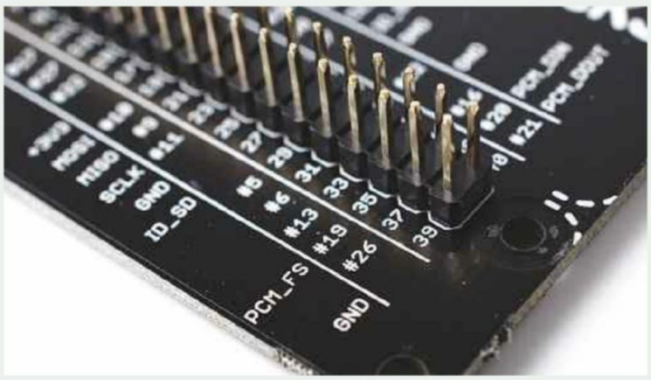

**Both the full-sized and mini variants attach to a Pi via a bundled 40-pin ribbon cable**

Both boards' feature sets are the same. Three headers are included: one connects to the Raspberry Pi's GPIO header with a ribbon cable, while another provides connections and mounting holes for a full-sized HAT or a Pi Zero-oriented pHAT board. The final header can be used to daisy-chain to another Black Hat Hack3r board, making use of pins that would otherwise be unused and inaccessible, or to sniff signals between the GPIO port and the HAT board for debugging or reverse engineering purposes.

By now, you should have a pretty good idea of whether or not you need the Black Hat Hack3r in your life. If your sole exposure to HAT boards is installing the one board you needed on top of a single Raspberry Pi, the Black Hat Hack3r isn't for you. For those who have need of it, though, it can be a life-saver – the development and debugging process at Pimoroni's workshop got a major shot in the arm when the design was perfected.

If you're a full-sized Pi user, there's only once choice for you: the original Black Hat Hack3r board, priced at £10 inc VAT for a kit that includes the board, ribbon cable, mounting hardware and three 40-pin headers, which you need to solder to the board yourself.

Pi Zero users get a wider choice: £4 inc VAT gets you a bare board, handy if you already have spare pin headers; £8 inc VAT gets you a similar kit to the full-sized Black Hat Hack3r set but cheaper thanks to the board's smaller size; and finally, a fully assembled version that's ready to go as soon when it's removed from the bag is available for £10 inc VAT. All models are available now from **https://shop.pimoroni.com**




**All pins are fully labelled, making connection considerably easier than on an unadorned Pi**

**If you're building HAT hardware for a Pi, the Black Hat Hack3rs are on your side**

ANALYSIS

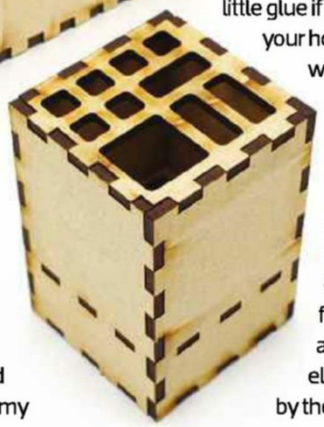
# Wim Van Gool's laser-cut tool holders

One of the biggest trends in the maker movement of the past few years has been the steady progression of manufacturing tools from industrial to hobbyist scale. My news feeds regularly light up with stories of people building low-cost CNC mills, 3D printers or laser cutters – and the threshold at which we call these devices 'low-cost' drops on a regular basis.

The result is that it's never been easier to buy (or to access via a hackspace or other collaborative workspace) the same sort of tools that are used for mass production. As the tools become more accessible, more people use them – naturally – and it becomes increasingly common to find hobbyists releasing the files needed to manufacture parts freely on the Internet. Such is the case with Wim Van Gool, a Belgian maker who has released three handy designs on **www.thingiverse.com** – a site primarily aimed at sharing 3D printer files, although it's also used to share files suitable for CNC milling, laser cutting and other automated production systems.

Having spotted Van Gool's designs online, but lacking a laser cutter of my own, I got in touch with my friend Aaron, who was only too pleased to slice the pieces out of low-cost medium-density fibreboard (MDF). For those who have never used a laser cutter before, the process is simple: load the vector files into the software, throw a sheet of material under the hood and set the device running. For more advanced users, there's the option of using tools such as SVGnest to minimise the footprint of material used by a project, but laser-cutting is no more difficult than traditional printing, albeit with the non-zero chance of a small fire if the laser mechanism gets stuck for any reason.

**If you too have a cluttered desk, have a look at sites such as Thingiverse for possible solutions**



**The miniature variant is especially useful for soldering tools and tiny screwdrivers**

Van Gool's designs attracted me because I struggle to keep my workspace neat and tidy. While a pencil-holder can do double duty as an organiser for many tools, the small yet long screwdrivers, tweezers and other tools you need when dealing with electronics can be awkward to sort – a problem Van Gool had also found and resolved using a clever multi-tiered tool-holder design.

Available in large and small variants, these holders are cut in two dimensions then assembled like a 3D jigsaw – the sides and solid base slot into each other with simple joints, while two or three upper layers contain the holes through which tools are inserted. The inner layers keep the structure straight, and in the larger model, some inner holes are smaller than upper holes, so tools that are bigger at one end than the other, such as screwdrivers or tweezers, are neatly centred.

Assembly is as easy as printing: there are no tools required, and the pieces fit together and are held in place by friction, although there's nothing to prevent you from adding a little glue if you want to be confident that your holder can bounce off the floor without coming apart. And the price is most definitely right: while multi-compartment organisers similar to Van Gool's design are available commercially, they're often expensive; cutting this design out of MDF takes a few pence worth of materials and less than a quid's worth of electricity. Even if you're paying by the hour for laser time, you should end up spending less on such a construction than the cost of a decent pint in a London pub. Wim Van Gool's designs are freely downloadable from Thingiverse at **http://tinyurl.com/wimvangool**

**Wim Van Gool's clever tool-holder designs fit together without tools or glue**

## NEWS IN BRIEF

### Google boosts Scratch

Block-based drag-and-drop programming language Scratch has received a shot in the arm from Google. Described as 'a new generation of graphical programming blocks', Scratch Blocks is based on Google's Blockly and will be released under an open-source licence as well as forming the heart of the official Scratch 3 release. 'Through our new collaboration with Google, our designs and ideas will become available to many more people, both developers and kids, around the world,' says the Scratch team.

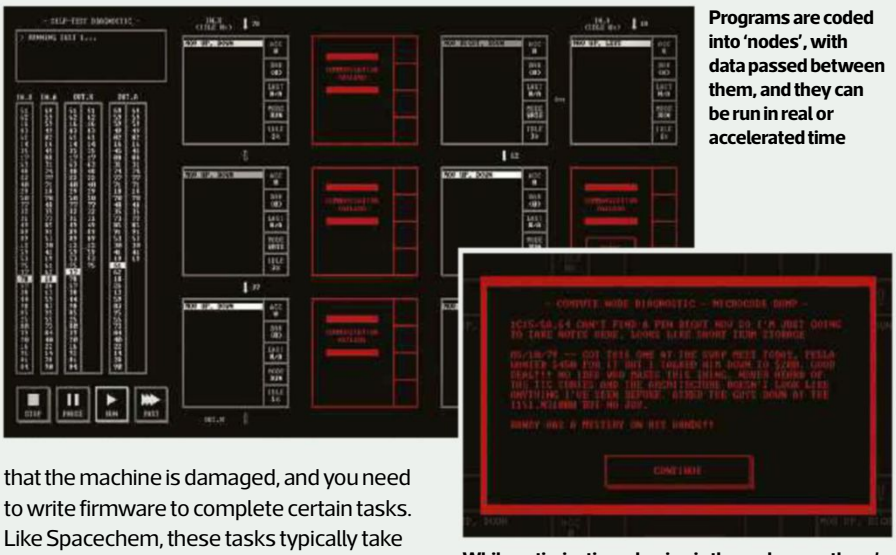
## REVIEW
# TIS-100

No, you haven't accidentally turned back to the gaming section; TIS-100 isn't a normal game. Created by Zachtronics Industries, the studio behind the popular Spacechem and better yet lesser-known Ruckingenur reverse-engineering simulators, TIS-100 will appeal to vintage computing enthusiasts while teaching some fundamental programming concepts.

TIS-100 starts with the advice that you should download and print the manual, a PDF that opens with a pseudo-handwritten note from 'Aunt Doris'. The note declares the family's sadness for Uncle Randy's death and confirms the supply of the vintage computer on which he was last working, the TIS-100 Tessellated Intelligence System, to you, his devoted nephew.

At its heart, TIS-100 is a programming simulator not dissimilar to Spacechem. The user interface, though, is pared down to basics: Zachtronics has opted for an 8-bit 1980s vibe, with stark white-on-black text boxes and a rather neat bootup sound that really triggers the nostalgia nerves. The TIS-100, as the manual explains in a short overview page, is a 'massively parallel computer architecture comprised on interconnected heterogeneous nodes' – a bit like some high-performance computers of the 1980s. As a fictional machine, though, it doesn't need to be entirely useful, which is why its instruction set is built up of a mere 14 instructions and five directions.

That's handy, because it's up to you to program it in assembly language. The idea is that the machine is damaged, and you need to write firmware to complete certain tasks. Like Spacechem, these tasks typically take the form of 'take something from input A and put it in output A', but as the game progresses, you need to perform increasingly complex operations on the inputs. Many of these operations would be easily achieved with a more complex instruction set, but require various tricks when you have limited resources available, a little like the tricks engineers of the 1980s would have genuinely used to get the most out of early home microcomputers.



**Programs are coded into 'nodes', with data passed between them, and they can be run in real or accelerated time**

**While optimisation-chasing is the real game, there's a paranoid plot too**

The killer feature of TIS-100, though, isn't the fun of coding in a made-up language for a fictional computer: it's the leaderboards. When purchased and installed through Steam, the leaderboard ranks your friends' efforts for the minimum resources used and the fastest execution time in cycles. The challenge, then, is not just to complete each level but to do so in a way that beats your friends' solutions – not easy if your circle of friends includes as many smart programmers as mine.

If you aren't playing leapfrog on the leaderboard, there's a plot of some description too: the corrupt nodes that serve to increase the difficulty of each level frequently contain note fragments from Uncle Randy, starting with his acquisition of the TIS-100 and detailing his descent into obsession with the machine and its secrets. The situation isn't helped by a highlighted note in the manual, which warns that documentation on Node Type T20 is restricted and that 'unauthorised requests for copies of documentation describing this node are reported to the state security bureau, as required by law' – complete with handwritten question marks, presumably added by Uncle Randy himself.

TIS-100 isn't for everyone. It isn't even necessarily a game for fans of Zachtronics' other works. However, if you're a vintage computing fan looking for a simple introduction to assembly language, or fancy competing on the leaderboards for the ultimate optimisations, it's a game I can easily recommend. TIS-100 is available on Steam now for £4.99 inc VAT. CPC

## NEWS IN BRIEF

### Arrow teams up with Indiegogo

Indiegogo has formed a 'strategic alliance' with Arrow, which will see Arrow hand-picking hardware projects from the site to offer support, ranging from design and prototyping services through to flash funding and even complete supply chain and manufacturing management. It's hoped that the deal will see fewer campaigns collapsing after receiving their crowd funds, as the magnitude of the task makes itself apparent.

**Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology.** @ghalfacree

DOWNLOAD FROM WWW.ASUS.COM/CAMPAIGN/REALBENCH

# CUSTOM PC REALBENCH 2015

## in association with ASUS

Give your PC a workout with our new benchmark suite, and see how your rig compares to other readers' machines

### BENCHMARK YOUR PC

Download the benchmarks from www.asus.com/campaign/Realbench and, before you run them, disable any power-saving technologies in your BIOS that change your CPU clock speed, or the leaderboard won't record your overclock frequency properly. To post a score on the leaderboard, go to Save Upload File in the RealBench 2015 app's Results menu, and save your results in an RBR file. You need to select Offline Uploads on the leaderboard site, sign up for an Asus account and upload your file.

### Gimp

We use Gimp to open and edit large images. Unlike our previous Gimp test, this one uses more than one CPU core, although it's still more sensitive to clock speed increases than more CPU cores.

### Handbrake H.264 video encoding

Our heavily multi-threaded Handbrake video encoding takes full advantage of many CPU cores, pushing them to 100 per cent load.

### LuxMark OpenCL

This GPU compute test is the only synthetic part of our suite, although the renderer is based on the real LuxRender physically based rendering software. As 3D rendering is a specific workload that not everyone will use, and because OpenCL support isn't standard in most software, this section is given just a quarter of the weighting of the other tests in the final score.

### Heavy multi-tasking

Our new multi-tasking test plays a full-screen 1080p video, while running a Handbrake H.264 video encode.

### Scores

RealBench 2015 breaks down the scores for each test, then gives you a total system score and a percentage reference score.

On an Intel system, the 100 per cent reference score comes from a stock-speed Core i7-4790K, with 16GB of Corsair 2400MHz DDR3 memory, a 240GB OCZ 150 SSD, an Asus Maximus Gene VII motherboard and an Nvidia GeForce GTX 780 3GB graphics card.

On an AMD system, the 100 per cent reference score comes from a stock-speed A10-7850K APU, with 8GB of Corsair 2,133MHz DDR3 memory, a 256GB Plextor M5 Pro SSD and an Asus A88X-Pro motherboard, using the APU's integrated graphics. CPC

### SHOUT OUTS!

**We have several new entries this month, firstly from mikey at number 11, and secondly from Nik, who has already bought a GTX 1080 card. Finally, congratulations to new entry charlescarter2015, whose overclocked Core i7-5820K rig has nabbed him the number 20 spot.**

### CHROME WARNING

At the moment, Google's Chrome browser flags up the RealBench 2015 download as potentially harmful, and we're aware of this issue. The file is perfectly safe, however – please ignore this warning.

## CUSTOM PC REALBENCH 2015 LEADERBOARD

| RANK | SYSTEM SCORE | REFERENCE | USERNAME | MOTHERBOARD | CPU | CPU CLOCK | MEMORY | PRIMARY GPU |
|---|---|---|---|---|---|---|---|---|
| 1 | 275,683 | 240.9% | 8pack | Asus Rampage V Extreme | Intel Core i7-5960X | 5.5GHz | 16GB Kingston 3000MHz | Nvidia GeForce GTX Titan X |
| 2 | 233,375 | 203.9% | ian.parry3 | Asus Rampage V Extreme | Intel Core i7-5960X | 4.6GHz | 32GB G.Skill 3200MHz | Nvidia GeForce GTX Titan X |
| 3 | 231,781 | 202.5% | CustomPC | Asus Rampage V Extreme | Intel Core i7-5960X | Not reported | 32GB Kingston 2666MHz | Nvidia GeForce GTX Titan X |
| 3 | 221,477 | 193.5% | Chris_Waddle | Asus X99-Deluxe | Intel Core i7-5960X | 4.62GHz | 16GB Corsair 3000MHz | Nvidia GeForce GTX Titan X |
| 4 | 219,415 | 191.7% | Luke@DinoPC | Asus Rampage V Extreme | Intel Core i7-5960X | 4.6GHz | 16GB Corsair 3276MHz | Nvidia GeForce GTX Titan X |
| 5 | 216,006 | 188.7% | terrystone1 | Asus Rampage V Extreme | Intel Core i7-5960X | 4.61GHz | 16GB Corsair 2992MHz | Nvidia GeForce GTX 980 Ti |
| 6 | 215,694 | 188.5% | dubai1 | Asus X99-Pro/USB 3.1 | Intel Core i7-5960X | 4.7GHz | 32GB Corsair 2800MHz | Nvidia GeForce GTX 980 Ti |
| 7 | 212,062 | 185.3% | TEL | Asus Rampage V Extreme | Intel Core i7-5960X | 4.62GHz | 16GB Corsair 2750MHz | Nvidia GeForce GTX 980 Ti |
| 8 | 211,331 | 184.6% | Menthol | Asus Rampage V Extreme | Intel Core i7-5960X | Not reported | 32GB G.Skill 3200MHz | Nvidia GeForce GTX 980 Ti |
| 9 | 208,975 | 182.6% | Angel | Asus X99 Deluxe | Intel Core i7-5960X | Not reported | 128GB G.Skill 2448MHz | Nvidia GeForce GTX 980 |
| 10 | 206,723 | 180.6% | stuart | Asus Rampage V Extreme | Intel Core i7-5960X | 4.41GHz | 16GB Corsair 3000MHz | Nvidia GeForce GTX 780 Ti |
| 11 | 200,464 | 175.2% | mikey | Asus Rampage V Extreme | Intel Core i7-5960X | Not reported | 16GB Corsair 3200MHz | Nvidia GeForce GTX 980 |
| 12 | 198,971 | 173.9% |  | Asus Rampage V Extreme | Intel Core i7-5960X | 4.4GHz | 64GB Corsair 2400MHz | Nvidia GeForce GTX 980 Ti |
| 13 | 197,964 | 173% | Carbonleg | Asus X99-E WS | Intel Core i7-5960X | Not reported | 32GB Corsair 2400MHz | AMD Radeon R9 200 Series |
| 14 | 189,230 | 165.3% | shadowsrayne | Asus Rampage V Extreme | Intel Core i7-5960X | 4.2GHz | 32GB Corsair 2133MHz | Nvidia GeForce GTX 980 |
| 15 | 188,136 | 164.4% | Nik | Asus Rampage V Extreme | Intel Core i7-5960X | 4.2GHz | 64GB Corsair 2666MHz | Nvidia GeForce GTX 1080 |
| 15 | 185,219 | 161.8% | dax | Asus Rampage V Extreme | Intel Core i7-5960X | 3.97GHz | 32GB Corsair 2448MHz | Nvidia GeForce GTX 980 |
| 16 | 181,058 | 158.2% | richcardnpaul | ASRock EP2C602 | Intel Xeon E5 2670 | 3.3GHz | 32GB Kingston 1866MHz | AMD Radeon R9 200 Series |
| 17 | 179,386 | 156.7% | mboogie | Asus Rampage V Extreme | Intel Core i7-5960X | 4.2GHz | 32GB Crucial 2133MHz | Nvidia GeForce GTX 980 |
| 18 | 177,350 | 155.0% | mauserk98 | Asus Rampage V Extreme | Intel Core i7-5930K | 4.63GHz | 16GB Team Group 3000MHz | AMD Radeon R9 200 Series |
| 19 | 175,745 | 153.6% | dis80786 | Asus Rampage V Extreme | Intel Core i7-5930K | 4.4GHz | 16GB Corsair 2666MHz | Nvidia GeForce GTX 970 |
| 20 | 175,493 | 153.3% | charlescarter2015 | Asus X99-Deluxe | Intel Core i7-5820K | 4.44GHz | 64GB Corsair 2370MHz | Nvidia GeForce GTX 970 |

ANTONY LEATHER'S

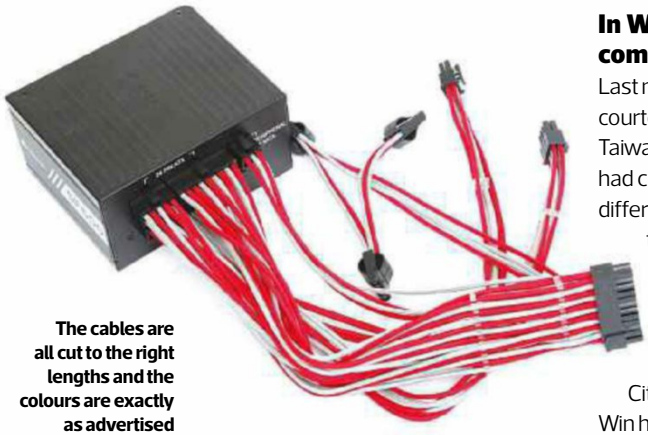
# Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

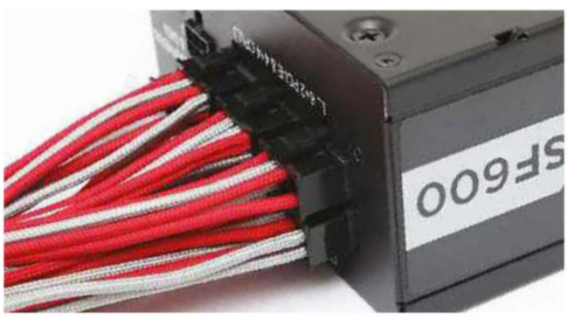
## Hands on with CableMod's PSU braids

Last month I mentioned CableMod's new online configurator (**https://store.cablemod.com/configurator**), which allows you to create custom cables for your PSU. And by 'custom', I mean that you can pick the colour of each cable strand and the type of the sleeving, the length of each replacement cable and the number of cables you want. The idea sounds fantastic – not only can you colour-match your cables to your case, but if you need shorter cables for a small PC, or longer ones for a multi-GPU behemoth, you could order your cables in the exact length you need.

Buying your cables pre-cut and braided saves a huge amount of time compared to doing the work yourself, and while the cost of a kit plus shipping will likely cost at least $130 (£90), the price is quite reasonable compared with many of the ready-made kits on offer, or indeed the price of third-party braiding, heatshrink and tools. A lot of people forget about just how much sleeving you need to completely sleeve all your PSU cables – just a 50cm 24-pin ATX cable requires 12m of sleeving.



**The cables are all cut to the right lengths and the colours are exactly as advertised**




**The connectors all fit perfectly and the cables look great**

Anyway, this week, the postman brought me my sample from CableMod, which includes cables for Corsair's new SFX 600W PSU. I have to say I'm very impressed. The cables are all cut to the right lengths and the colours are exactly as advertised, while the connectors all fit perfectly and look great too. Sleeving your own cables is seen by many as a rite of passage when it comes to PC modding, but I would much rather spend the time – usually at least 48 hours – spraying or customising my case in other ways. I'll likely be using CableMod's service quite a bit in the future.

## In Win Mod in Taiwan competition

Last month I headed to Taiwan courtesy of In Win to cover its Mod in Taiwan competition. The company had chosen eight teams from seven different countries to compete in a three-day modding event to mark its 30th anniversary, with just 24 hours of tool time to mod their cases. The event was held at In Win's factory in Taoyuan City a few miles from Taipei, but In Win had kitted out a whole room with a vast array of tools, paints, hardware and water-cooling gear – essentially all the equipment the modders needed. I also had a quick look around the factory while I was there, which was currently dishing out the company's 303 case.

There were a few hiccups, such as a lack of paint primer, and the acrylic glue In Win provided wasn't fast-drying either. However, all the teams were up against it in terms of time, and it was fascinating to see the projects come together so quickly. Teams from France, the USA, Sweden, China, Germany, Australia and the UK went head to head with eight very different projects using different materials adhering to three themes.

The first day saw plenty of cutting, sanding and commotion as the teams grappled with their new 509 cases,

**In Win's modding competition saw some great mods completed in just 24 hours, with teams from the UK (left), China (middle) and Sweden (right), among others**

while EKWB and Bitspower were on hand to make sure everyone had all the water-cooling gear they needed. The second day saw the teams deal with their main customisations. For example, the UK team (made up of Dave Alcock and Daniel Harper – both of whom have featured in our Readers' Drives section) and Swedish team were spraying their cases inside the In Win factory's heated spray booths.

Meanwhile, the German team featured the Blass brothers, who are well known for their acrylic exploits, so it was no surprise to see them chopping up a mound of green acrylic, which they later laid under metal panels. Their showpiece, though, was a custom acrylic reservoir they'd made by splitting an existing EK reservoir into two pieces. Other notable entries were the Chinese and Swedish teams, with particularly clean-looking water-cooled builds. It was a great experience and the winner, who will be decided after voting finishes, will see a limited production run of their case roll off In Win's production line. In the meantime, you can see all the finished mods at **http://mod.in-win.com**

## Dan Cases A4-SFX

While the Dune Case I mentioned two issues ago failed to gain enough traction on Kickstarter, another dinky small form factor case has smashed its funding target and is on course to be shipped in December this year. The Dan Cases A4-SFX is the brainchild of Daniel Hansen from Germany, who has managed to get his designs picked up by Lian Li. The company has already made a limited production run of the A4-SFX case, and now there are nearly 1,300 backers pledging a minimum of €230 each for a sample.

Dan Cases claims the A4-SFX is the smallest mini-ITX case that can house an SFX or SFX-L PSU, a full-sized graphics card and several 2.5in SSDs. The case has an unusual layout, with a high-quality PCI-E riser cable allowing the graphics card to sit behind the motherboard. There isn't a lot of room for CPU coolers though; there's only just enough space for an Intel stock cooler. However, some low-profile coolers we've seen can handle moderate overclocks, and the case is well ventilated too. The CPU height limit stands at 48mm, so you'll need a very low-profile cooler such as Phanteks' PH-TC90LS or Noctua's L9i. Unless you can figure out a way of using a pump and radiator externally, there's also no way to install any form of liquid cooling either.

**Dan Cases claims the A4-SFX is the smallest mini-ITX case that can house an SFX PSU**

The biggest selling point, though, is its dimensions. It measures only 110mm wide, 200mm high and only a little longer than 300mm, giving it a volume of just 7.25 litres. Despite these dimensions, though, dual-slot graphics cards up to 295mm long can be squeezed inside the case, along with three SSDs and up to an SFX-L PSU, which is essentially a near standard-length PSU, but with reduced height and larger, quieter fans. The case is made using 1.5mm aluminium and features pop-on side panels that Lian Li has used in a number of its other cases.

If you just want a truly tiny desktop PC for gaming, then you can find out more information about the A4-SFX at **www.dan-cases.com**, although €230 (around £177) looks a bit steep for such a small, featureless case to me. CPC

**Antony Leather is Custom PC's modding editor** @antonyleather

# How to Spray-paint your PC

Spraying your case with a new colour is both easy and affordable. Antony Leather shows you how to do it

**TOTAL PROJECT TIME** / 48 HOURS

Spray-painting your PC case is the most dramatic way to make your PC look snazzy and unique. There are thousands of colours from which to choose, as well as effects that add glitter, marbling, and all manner of weird and wonderful appearances. It's relatively easy to achieve a good finish too, especially in warm weather, and practically any case is suitable.

However, you'll need couple of days to spray and allow the paint to dry, and you'll also need a medium-sized open space or garage and a protective mask and gloves.

## TOOLS YOU'LL NEED

Montana Gold primer, colour, varnish and marble spray paints / www.globalartsupplies.co.uk

Montana spray caps / www.globalartsupplies.co.uk

1,500-grit sandpaper / Most hardware stores

Car polish / Most hardware stores

Rivets and rivet gun / Most hardware stores

Protective latex or nitrile gloves / www.montanapaints.co.uk

Sugar soap or rubbing alcohol / Most hardware stores

Face mask / https://airbrushes.com

### 1 / PICK COLOURS

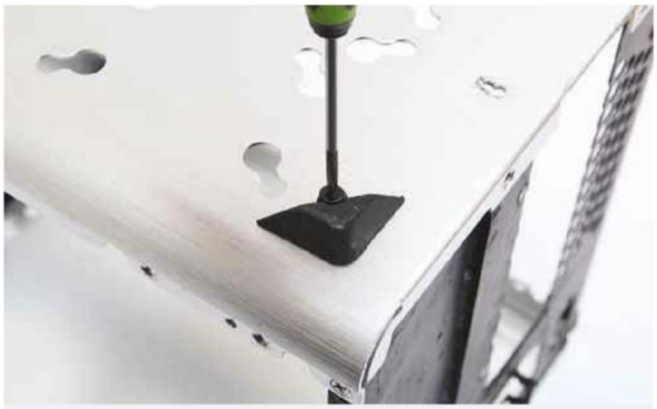
Picking your colour is a tough decision – there are thousands of different colours from which to choose, and you can consider metallic and other effects too. We've chosen Montana Ultramarine blue, along with a marble effect spray, plus primer and varnish.

### 2 / CHOOSE PARTS TO SPRAY

You may want to only paint the exterior, as spraying the interior as well can use a lot of paint. You can also paint drive bays and the motherboard different colours. Try using a pencil drawing or Google's SketchUp to see how your case will look.

### 3 / RIVETS OR SCREWS

Find out whether your case is held together with rivets or screws, or both. You'll need to completely dismantle the case to get the best results, and this process will be much easier if your case is screwed together.



### 4 / REMOVE DRIVE BAYS AND FEET

Remove any fittings you don't want to paint, including internal drive bays, especially ones you won't use anyway, and also rubber case feet.

### 5 / REMOVE FRONT PANEL BUTTONS

If you want to paint the front panel buttons, you'll need to do this job separately. Don't spray them in situ, as the paint will act like glue and render them inoperable. Also, remove any ports or audio jacks.

### 6 / REMOVE WINDOW

Side windows can usually be removed by removing screws that hold them in place, although many windows are also secured using metal flanges. It's far quicker to remove the window, rather than mask it, if possible.

### 7 / CUT WINDOW OR RADIATOR BLOWHOLES

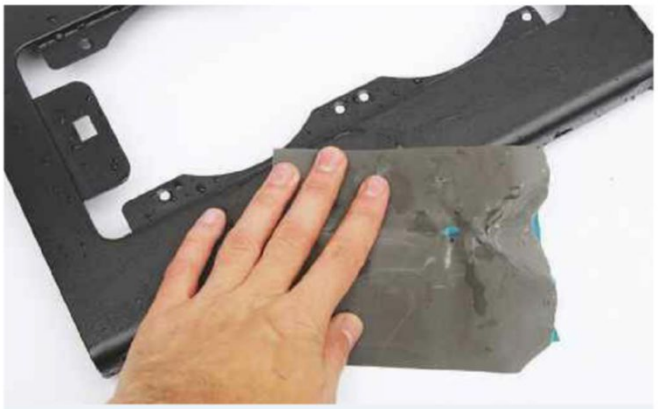
If you intend to cut out radiator blowholes or windows in your case, do it before you paint the case, using a Dremel or jigsaw. You'll risk damaging the paint if you do it later, leaving unsightly edges.

### 8 / FILE EDGES AND USE FILLER

If there are any significant scratches in the case, fill them prior to painting, as primer won't be able to completely fill them. 3M Glazing Putty is a light filler that's ideal for masking over scratches; apply it with an old credit card before sanding it flat.

### 9 / DRILL OUT RIVETS

If you case is riveted together, you'll need to drill out the rivets to dismantle the case and, of course, rivet it back together afterwards with replacement rivets and a rivet gun. Use a drill bit that's a little smaller than the rivet end.



## 10 / SAND CASE

Sand the case with 1,000-grit sandpaper prior to applying primer to smooth over any rough edges or bumps and allow the paint to adhere to the surface. This step is especially important if your case has been pre-painted or has a glossy plastic finish.

## 11 / USE PROTECTIVE GLOVES

To save time scrubbing your hands after painting, use disposable gloves, or durable gloves that are specifically designed for painting. The gloves will also prevent you from getting fingerprints on the case after you've cleaned it.

## 12 / WASH WITH LINT-FREE CLOTH

Even more important than sanding is cleaning. Fingerprints, muck, grime and thermal paste can wreak havoc on a paint finish so, while wearing your gloves, use rubbing alcohol or sugar soap to clean all the paint surfaces.

## 13 / PREPARE PAINT AREA

It's best to spray outside in terms of ventilation, but you'll be at the mercy of flies and risk annoying people nearby. A garage makes a good alternative, but use a face mask and goggles in both cases and prepare the area with dust sheets first.

## 14 / WARM PAINTS

A trick to aid paint drying in typical British weather is to warm the cans in warm water first. Only use bath-hot water, rather than boiling water from a kettle.

## 15 / FIT SPRAY HANDLE

If you find your fingers get tired after spraying for long periods, Plastikote's spray trigger is a great device that uses a trigger grip for easier use. It's compatible with most spray cans too.

## 16 / MARK UP CASE

Mask any areas you don't want painted, using Frog tape for larger sections and edging tape for thinner lines and curves – we'll be keeping the chrome edges on our case. However, you'll need to remove the masking prior to the varnish coat.

## 17 / USE DIFFERENT NOZZLES

Montana offers a pack of different-sized nozzles for different spray types – you want a wide spray for primer and narrower sprays for colour and varnish. Shake the cans well and test them with different nozzles on cardboard to see which combination works best.

## 18 / SPRAY PRIMER

Primer acts as a base for the colour coat, while smoothing over the surface. Apply it generously in single coats, allowing each coat to dry. Move the can rapidly back and forth over the case section, making horizontal lines. Continue until all underlying marks are covered.

## 19 / SAND IF NECESSARY

It's often necessary to sand the primer to create a super-smooth layer for the colour coat. Use 1,500 or higher-grit sandpaper and lightly rub it with water. If need be, sand lightly over each coat of primer, washing off the residue before applying the next coat.

## 20 / SPRAY COLOUR COAT

Apply a thin colour coat over the whole section, moving at around 12in per second from left to right, then let the paint dry. Don't apply too much paint, or it may run. If necessary, you can sand it once it's dry. You'll need three or four coats to completely cover the section.

## 21 / SPRAY EFFECT COAT

When the colour coat is dry, apply the effect coat. We've opted for Montana White Marble, which is a bit like fine silly string. You need to move the can rapidly over the surface – it's best to practise first on some cardboard, but one pass is usually enough.

## 22 / REMOVE MASKING

With the colour and effects coats dry, it's time to prepare your case for the varnish coat. Remove any stray strands of marble effect string from the section, if you used it, and remove the masking, using a knife to clean up the paint edge if necessary.

## 23 / SPRAY VARNISH COAT

Apply the varnish in slow, generous coats from left to right, so you can see it build up in a cohesive layer, rather than bobbles. If you've used the marble effect, you'll need at least five varnish layers to cover it; otherwise, three or four layers are enough.

## 24 / USE CAR POLISH

Leave the varnish to dry for 24 hours then inspect the finish. If there are any pits, you can apply more varnish to fill them. Once it's dry, use car polish such as T-Cut to create an even surface on gloss paints.

## 25 / BUFF TO A SHINE

Using plenty of elbow grease, buff the finish to a shine using a clean cloth. Repeat this process with more T-Cut if necessary, just as you would with a car. This process is gently abrasive and will create a brilliant shine.

## 26 / USE RIVETS AND RIVET GUN

If you had to drill out rivets, put your case back together using a rivet gun. Use rivets that are a little smaller than the rivet holes in your case; place the tail in the gun and squeeze it tight with the rivet in the hole. The tail should snap off, securing the two sections together.

## 27 / REASSEMBLE CASE

Reassemble the rest of the case with screws or rivets. The paint will be fairly delicate, even after the varnish has dried, so don't bash it, as it will likely scratch. If any sections don't fit together, gently sand the contact points to wear down a little paint. CPC

# Folding@Home

## MILESTONES THIS MONTH

| USERNAME | POINTS MILESTONE |
|---|---|
| richardjohn22 | 20000 |
| Daedalus | 40000 |
| enciem | 50000 |
| ewink20 | 60000 |
| Prince_Knight | 60000 |
| Tonyb959 | 70000 |
| ShavedCloaca | 80000 |
| AJJackson1 | 90000 |
| LE_DANK_MEMES | 90000 |
| crisderaud | 100000 |
| whiskeyecho | 100000 |
| Goldmaster | 200000 |
| havedCloaca | 200000 |
| Nex79 | 200000 |
| guitarbenji | 300000 |
| Pugheaven | 300000 |
| suggestable | 300000 |
| trma97 | 300000 |
| mar_duke | 400000 |
| OrigamiMasters | 400000 |
| BenjieB | 500000 |

| USERNAME | POINTS MILESTONE |
|---|---|
| Girder_Gibbon | 500000 |
| Mr_Blue_Jam | 500000 |
| Pickles96 | 600000 |
| Anselm | 700000 |
| anadir | 800000 |
| Ayeska | 800000 |
| ggyenyen | 800000 |
| FREE_WORLD | 900000 |
| Rykard_Maximus | 900000 |
| crazeey | 1000000 |
| Epwin | 1000000 |
| chris_bradford | 2000000 |
| grozzie | 2000000 |
| Lunnbow | 2000000 |
| markf0wle | 2000000 |
| NFGCS | 2000000 |
| siddallj | 2000000 |
| Techie_Taylor | 2000000 |
| mort6dav3 | 3000000 |
| PCEnthusiastUK | 3000000 |
| shadybk | 3000000 |

| USERNAME | POINTS MILESTONE |
|---|---|
| Aardwork | 5000000 |
| LEACHIE007 | 5000000 |
| Tango_Echo_Alpha | 5000000 |
| ghodula | 6000000 |
| Reiep | 6000000 |
| smiler | 6000000 |
| wew | 6000000 |
| jonesd98 | 7000000 |
| Mauri | 7000000 |
| PURE | 7000000 |
| Bobthetoolnut | 8000000 |
| scoobyzilla | 8000000 |
| ZeDestructor | 8000000 |
| Maverick | 9000000 |
| QuasarGreg | 9000000 |
| RaistlinRTCW | 9000000 |
| valkynaz | 9000000 |
| Acanuck | 20000000 |
| Allan_Smith | 20000000 |
| BCFC_WSM | 20000000 |
| chin913 | 20000000 |

| USERNAME | POINTS MILESTONE |
|---|---|
| clanseven | 20000000 |
| Brentwood-Computers.com | 30000000 |
| dd | 30000000 |
| gupsterg | 30000000 |
| Dave_Laffin | 40000000 |
| debs3759 | 40000000 |
| Little_Willie | 60000000 |
| Geoff_Ashden | 70000000 |
| Qazax | 70000000 |
| SirBenjaminNunn | 70000000 |
| Angy | 80000000 |
| PS3/LanDi | 80000000 |
| slowpurple | 90000000 |
| 8Core | 100000000 |
| Unicorn | 100000000 |
| daxchaos | 200000000 |
| Laguna2012 | 500000000 |
| Lordsoth | 700000000 |
| piers_newbold | 1000000000 |

## WHAT IS FOLDING?

Folding@home uses the spare processing cycles from your PC's CPU and graphics cards for medical research. You can download the client from **http://folding.stanford.edu** and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag. You can also discuss folding with us and other readers online at the **www.bit-tech.net** forums.

## TOP 20 OVERALL

| RANK | USERNAME | POINTS | WORK UNITS |
|---|---|---|---|
| 1 | Nelio | 2,668,499,774 | 222,120 |
| 2 | DocJonz | 2,435,174,603 | 199,861 |
| 3 | HHComputers | 1,927,294,448 | 56,335 |
| 4 | piers_newbold | 1,017,581,155 | 61,213 |
| 5 | Scorpuk | 958,228,502 | 36,233 |
| 6 | coolamasta | 935,762,977 | 185,904 |
| 7 | Lordsoth | 709,716,202 | 106,187 |
| 8 | PC_Rich | 679,164,270 | 88,655 |
| 9 | StreetSam | 571,113,589 | 90,251 |
| 10 | Slavcho | 544,995,379 | 39,458 |
| 11 | johnim | 525,309,957 | 83,093 |
| 12 | Laguna2012 | 501,150,674 | 29,070 |
| 13 | Dave_Goodchild | 465,923,185 | 119,946 |
| 14 | The_M2B | 430,275,695 | 65,795 |
| 15 | Desertbaker | 385,221,726 | 24,436 |
| 16 | apeman556 | 349,736,464 | 32,529 |
| 17 | KevinWright | 335,349,856 | 34,094 |
| 18 | Dickie | 289,534,045 | 26,508 |
| 19 | TheFlipside | 258,227,871 | 26,020 |
| 20 | phoenicis | 250,044,587 | 95,660 |

## TOP 20 PRODUCERS

| RANK | USERNAME | DAILY POINTS AVERAGE | OVERALL SCORE |
|---|---|---|---|
| 1 | HHComputers | 5,038,921 | 1,927,294,448 |
| 2 | DocJonz | 4,360,822 | 2,435,174,603 |
| 3 | Lordsoth | 1,728,252 | 709,716,202 |
| 4 | Scorpuk | 1,591,717 | 958,228,502 |
| 5 | piers_newbold | 1,265,679 | 1,017,581,155 |
| 6 | apeman556 | 1,055,143 | 349,736,464 |
| 7 | Geoff_Ashden | 1,024,749 | 70,662,350 |
| 8 | Laguna2012 | 973,325 | 501,150,674 |
| 9 | Nelio | 886,468 | 2,668,499,774 |
| 10 | PC_Rich | 803,866 | 679,164,270 |
| 11 | Desertbaker | 789,728 | 385,221,726 |
| 12 | Unicorn | 729,459 | 108,213,990 |
| 13 | Slavcho | 653,048 | 544,995,379 |
| 14 | madmatt1980 | 615,389 | 160,424,403 |
| 15 | KevinWright | 589,207 | 335,349,856 |
| 16 | daxchaos | 500,377 | 232,547,131 |
| 17 | BeezaBob | 497,310 | 192,810,834 |
| 18 | SirBenjaminNunn | 369,584 | 77,723,458 |
| 19 | Qazax | 295,035 | 79,373,269 |
| 20 | The_M2B | 285,848 | 430,275,695 |

# Readers' Drives

## Three Leaves Daylight

Sebastian Edemalm wasn't afraid to jump in at the deep end with his first PC build – getting a Deepcool Tristellar four months before release and designing a rigid water-cooling system

### /MEET THY MAKER

**Name** Sebastian Edemalm (aka eucalyptus)

**Age** 19

**Location** Katrineholm, Sweden

**Occupation** Just graduated in electrical engineering and computer science at high school, with five years of business and economics waiting around the corner at university next year

**Main uses for PC** Everything, from gaming to web surfing

**Likes** Travelling, food, cars and technical innovations – I like to play around with LEDs. A great movie is always appreciated too

**Dislikes** Snails – I can't go outside when it's raining!

**CPC: What originally inspired you to build Three Leaves?**

**Sebastian:** This is the first PC I've built on my own. I've always been interested in computers and other electronic hardware, but I was using gaming laptops until this project was completed. I first thought about building my own PC back in April 2015, and at the same time, I first saw a picture of the Deepcool Tristellar as a prototype. I also think it was this same month when I saw the news about Acer's upcoming Predator X34 monitor. Like most people, I could only dream of this gear at this time, but I was then offered a very sought-after contract for a summer job at Ericsson in my home town of Katrineholm in Sweden.

With some money coming in, I finally said, 'Yes, I'll build my own PC!' in June last year. I started taking a look at different forums, mostly on Overclock.net, and I also had to choose a case. I was really sold on the Corsair Carbide 540 and the In Win S-Frame at this time. I'd still love to make a water-cooling project with the Carbide 540, but I soon saw on Overclock.net that thousands of people already had done amazing builds with these cases. I wanted to do something else. With the money from my summer job, I had no limits, and I'd already decided I wanted a unique PC. You know when you see something so fantastic that you almost want to cry, and feel the hairs on your arms rising? I wanted to build a system that could create those feelings.

I wanted to use the Deepcool Tristellar, but it wouldn't be released until four months later, so I contacted Deepcool, which let me buy one of the first five handmade versions for the European market; it cost me almost twice the release price. I also managed to get a discount from the Danish water cooling company Coolerkit. I contacted a guy called Mads, who was the only person who believed in me when I didn't have a portfolio. All my spare time last summer was then spent watching JayzTwoCents and LinusTechTips on YouTube, so I could learn as much as possible, especially about water cooling.

**CPC: What does the name mean?**

**Sebastian:** There isn't really a history behind the name. I don't even know where my internet forum alias 'eucalyptus' comes from; it's probably from the eucalyptus candy pastilles from my childhood. The project name just matches the theme, being inspired by our planet's beautiful nature and woods. Each of the three Samsung SSD also have one big leaf painted on them, which gives you a total of three leaves.

**SEE THE FULL PROJECT LOG:** http://tinyurl.com/ThreeLeaves

**CPC: What difficulties did you come across?**

**Sebastian:** Wow, the amount of issues and struggles I faced during this journey is huge! For example, when I first started filling my water-cooling loops with my little brother in the garage, the whole thing started to leak like a big, expensive fountain. Also, once I finally got the whole system to work, on a Sunday night back in March or February this

year, my ASRock motherboard died, and it was hard to get it replaced.

I've been so close to throwing this whole project away so many times – many of the problems have been painful. What's more, I couldn't tell my dad if I'd failed. He'd tried to convince me a hundred times before I started not to do it, saying it's too much money and I didn't know what I was getting into. As always, I didn't listen, which I sometimes regretted, but not when it was working.

I still remember when I launched my project logs on Sweclockers (Sweden) and bit-tech. I used many glamorous words about how great my vision would be. In Sweden, many of the modders criticised me, but the people on bit-tech said how great my work was, perhaps showing a difference between these nations and cultures when it comes to modding. I'm still thankful for all the support I got from the bit-tech and SweClockers communities – they're the people who made me want to continue and finish.

**CPC: Why did you use rigid tubing?**
**Sebastian:** There's nothing more beautiful than a pair of tubes in a perfect line – it's all about clean and smooth aesthetics – soft tubing is never an option in my opinion.

**CPC: What tools and machinery did you use?**
**Sebastian:** I only used hand tools, except for the Monsoon 90-degree fittings in the front, which were drilled and tapped by a lathe to make an exact perfect G1/4 thread. I wish I had the fancy tools that some professional modders own, so I could make more advanced stuff with acrylic and metal, but you can only use what you have.

**CPC: What interest has this project attracted?**
**Sebastian:** I'm still the young boy from the forests of nowhere in Sweden. When I launched my builds logs, and the number of views dramatically increased by thousands I fell off my chair. Right now, my build logs have had almost 20,000 views on Sweclockers, and over 13,000 on bit-tech. I also won Mod of the Month in the April competition on bit-tech, which is one of the biggest rewards a PC enthusiast can achieve. In addition, my project had been shared multiple times by big companies, including XSPC, Coolerkit, Deepcool and a few others. Even Nvidia just recently asked if it could share it. I mean, come on, Nvidia? I still think this is a dream from which I have to wake up.

**CPC: How long did the build take?**
**Sebastian:** It took approximately 300 hours for just the building, not including the time spent planning, designing and so on. I started to work with the case back in August 2015, and finished it in March 2016.

**CPC: What did you learn from the build process?**
**Sebastian:** Everything! What to do, and what not to do, as well as coming up with strategies and ideas for future projects. At the time, I said to myself that Three Leaves is the first and probably most extravagant idea I'll execute, but I've now just signed up with Aquatuning and Blacknoise Technologies to make another water-cooling project – imagine the design of a V8 engine, and the power of a V12.

**CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?**
**Sebastian:** I'm happy with it, but if I started all over again, I would opt for a normal computer with air cooling, rather than making more problems for myself than necessary. CPC

## BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your mod needs to be fully working and, ideally, finished based in the UK. Simply log on to **www.bit-tech.net** and head over to the forums. Once you're there, post a write-up of your mod, along with some pics, in the Project Logs forum. Make sure you read the relevant rules and advice sticky threads before you post. The best entrant each month will be featured here, where we'll print your photos of your project and also interview you about the build process. Fame isn't the only prize; you'll also get your hands on a fabulous selection of prizes – see the opposite page for details.

## SYSTEM SPECS

**CPU** Intel Core i7-5820K

**Graphics card** EVGA GeForce GTX 980 Ti Hydro Copper

**Case** Deepcool Tristellar

**Memory** 16GB (2 x 8GB) HyperX Fury DDR4 2666MHz

**Motherboard** ASRock X99E-ITX/AC

**Storage** 2 x 500GB Samsung 850 Evo, 1 x 128GB Samsung SM951 NVMe and 1 x 1TB Samsung 850 Pro

**PSU** Superflower Leadex 850W Platinum

**Cooling** Custom water-cooled separate CPU and GPU loops, consisting of many different brands and more kit than is listed here. Monsoon Hardline Free Center fittings, two EKWB XE 120mm radiators with Vardar fans, four XSPC D5 Photon 170 reservoirs and EKWB waterblocks

# Win all these prizes!

We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

## Corsair graphite Series 230T case and RM 550w Modular power supply

**TOTAL VALUE** £150 inc VAT / **MANUFACTURER** www.corsair.com

Corsair believes that a great PC starts with a great case. The Corsair Graphite Series 230T is a compact expression of this core philosophy. With stylish looks and a choice of three different colours, it packs in a remarkable number of features to provide builders with tonnes of room for expansion and amazing cooling potential. Like all Corsair cases, it's built using the finest materials and finished to the highest standards, so it will withstand several years of upgrades. Plus, to make sure it stand outs from the crowd, the 230T features Corsair's new Air Series LED high-airflow fans, providing distinctive lighting with low-noise, high-airflow cooling.

Just as a quality case is essential to building a quality PC, a high-performance, a high-quality power supply is also a vital ingredient. The all new RM series has been built from the ground-up to deliver unmatched reliability alongside 80Plus Gold efficiency, and all with the absolute minimum of noise. It uses specially optimised quality parts to reduce sound at the component level, and it's completely silent below 40 per cent load, thanks to its Zero RPM fan mode. It's also fully modular, allowing for the maximum amount of flexibility during installation. With a Corsair Graphite 230T case and an RM 550W Modular power supply at the heart of your build, you'll have the foundations for a truly awesome gaming machine.

## Mayhems coolant and dyes

**VALUE** £50 inc VAT / **MANUFACTURER** www.mayhems.co.uk

Cooling performance is only one part of the equation when it comes to kitting out your rig with custom water-cooling gear. The other major bonus is that all those tubes and gleaming fittings just make your PC look damn sexy, and they look even better when they're pumped full of fancy coloured coolant. As such, we're particularly pleased to have the folks at Mayhems now on board with Readers' Drives; they're currently offering two 1-litre bottles of Mayhems' Pastel Ice White coolant, along with a selection of five dyes, so you can choose the colour that best complements your PC. Check out the blue coolant in our own mini PC mod on the cover of Issue 109 for an example of what's possible with some Mayhems coloured coolant.

## Phobya Modding Kit

**VALUE** £50 inc VAT **MANUFACTURER** www.phobya.com, www.aqua-tuning.co.uk

The Phobya modding kit is designed with the modder in mind, offering great value for money and quality products. The kit includes Nano-G 12 Silent Waterproof 1,500rpm multi-option fans, which use an innovative fan-blade design. As standard, the fans include braided black cables to keep your case looking as neat as possible. The fans are also supplied with a special cable that lets you run the fan at 5V rather than 12V, reducing the noise emitted in order to help you to build a silent system.

The kit also includes the 60cm Phobya 3-pin Molex to 4x 3-pin Molex Y-cable. This pre-braided extension cable gives you extra routing options in your case, and it also enables you to run up to four fans from one compatible motherboard header. Meanwhile, the Phobya SATA 3 cables included in the kit offer the same great quality braiding as the rest of the Phobya range, while also securing your connection with latched connectors.

As well as this, the kit includes the Phobya SlimGuide Controller, which gives you the option to vary the speed of other fans in your case, while the Phobya TwinLEDs let you shine a light on your mods.

**JAMES GORBOLD** / HARDWARE ACCELERATED

# THE GRAPHICS WAR IS ON

AMD's new RX480 is the company's most competitive and compelling GPU in a long time, argues James Gorbold

While AMD is faring much better in the graphics card business than the CPU market, for the past few years it's still played second fiddle to Nvidia, with its steadily declining market share hurting revenue, as well as the amount available to spend on research and development. However, after years of inertia, it looks as though AMD's fortunes might turn around with the launch of the Radeon RX480, based on the new Polaris architecture.

What makes the Radeon RX480 so much better than the R9 300-series cards is that it's made using 14nm FinFET transistors, as opposed to the much larger 28nm transistors used to make AMD's earlier GPUs.

Smaller transistors not only switch faster, but they also consume less power, so the RX480 has more stream processors than you would expect for its price tag, and it can also run at a high frequency too.

The end result is that the Radeon RX480 can stand toe to toe with the hugely popular Nvidia GeForce GTX 970. As with any graphics card comparison, the performance delta varies between games, but the big picture is that the RX480 is on a par with a GTX 970. In real-world terms, this means the RX480 is a great card for gaming at 1,920 x 1,080 and 2,560 x 1,440. For example, in the latest Doom game (which really should be called Doom 4), you can expect to experience around 80fps at 1,920 x 1,080 and 53fps at 2,560 x 1,440 *(**Ed:** Yep, those figures correspond with the averages in our tests on p19)*. Unlike the recent Radeon R9 390 and 390X GPUs, the RX480 also runs cool and doesn't consume a ridiculous amount of power.

> The Radeon RX480 can stand toe to toe with the hugely popular Nvidia GeForce GTX 970

Unfortunately (or perhaps I should say 'unluckily') for AMD, though, with the UK in the midst of post-referendum chaos, the pound's value against the dollar has dropped significantly, which is bad news for a new hardware launch. As a result, if you look around, you can find pre-overclocked GTX 970s for a similar price to the RX480, although these are admittedly 4GB GTX 970 cards compared with the cost of an 8GB RX480.

Also, some of these deals can be further improved by cashback offers that are available at the moment on some EVGA GTX 970 cards. Of course, the price of the GTX 970, along with practically every other tech product, will likely be heading upwards soon too, but while RX480 stock has only just arrived, there's a good inventory of the GTX 970 in the channel, so its price won't shoot up any time soon.

Still, regardless of global economics and national turmoil, it's great to see AMD introducing the RX480, which is easily its most competitive and compelling graphics card in a long time. It will certainly be interesting to see how sales of the RX480 and GTX 970 compare over the next few months.

All that said, **Custom PC** is a PC enthusiast mag, and I'm a performance hound, so I can't get too excited about distinctly mid-range cards such as the Radeon RX480. It's definitely good, but it simply doesn't have the horsepower I'm looking for and, at the high end, Nvidia still rules supreme with the GTX 1080 and GTX 1070. To see any real change there, AMD needs to get its Vega GPUs with HBM2 memory out the door sooner rather than later. CPC

**James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.**

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